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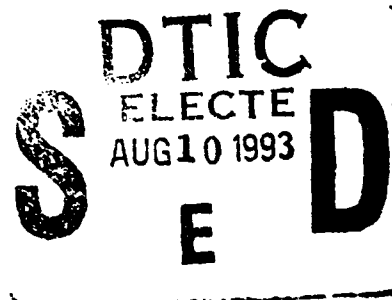
**ANALYSIS OF BOLTED AND BONDED  
COMPOSITE JOINTS**

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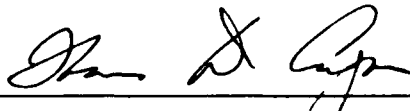
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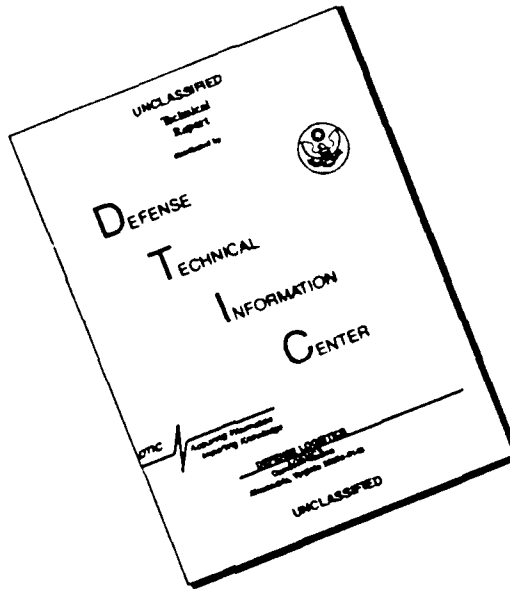


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13. ABSTRACT (Maximum 200 word.) <p>In the analysis and design of bonded and bolted composite joints, certain input data are required that are not readily available. Many engineering hours at the depots are expended in obtaining the required information. Even when the data are obtained, the accuracy of it is sometimes questionable. The availability of this information in a computerized database would greatly facilitate composite joint analysis and design.</p> <p>The work described in this report involved an extensive search of the technical literature for adhesive and composite material property data as well as bonded and bolted joint properties. The data collected in the literature search were tabulated into a user friendly format for ready retrieval.</p> <p>The data in this tabulation include, in addition to material properties, discussions of fastener and joint design parameters, loading and environmental effects and test methods.</p>				
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Adhesive	Environmental Effects	Mixed Mode
Bearing	Failure Mode	Mode I
Bolt Pattern	Fastener	Mode II
Bolted	Fatigue	Mode III
Composite	Hybrid	Properties
Creep	Joints	Shear
Database	Lamina	Stress Relaxation
Design	Lap Shear	Stress-Strain
Effects	Loading Types	Test Methods
Elevated Temperature		

## PREFACE

This report covers work performed during the period from May 1991 to June 1992 under Air Force Contract F33615-89-C-5643. The work was performed by Wright Materials Research, evaluated by the University of Dayton Research Institute, and administered under the direction of the System Support Division of the Wright Laboratory, Wright-Patterson Air Force Base, Ohio. Mr. Robert Urzi was the program Project Engineer. The author would like to thank Capt. R. Keller of SM-ALC/TIEC, Mr. R. Askins of the University of Dayton Research Institute, Mr. J. Mazza, Mr. N. Ontko and Mr. M. Forte of WL/MLSE for the review of this report.

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# **Chapter 1**

## **Bolted Joints in Laminated Composites**

### **1.1 INTRODUCTION**

The study of bolted joints of laminated composites consisted of a literature search in the following publications: Composite Structures, Composites, Journal of Composite Materials, American Society For Testing and Materials (ASTM) Special Technical Publication (STP), AIAA Proceeding and Journal of AIAA, Proceeding of Society of Experimental Mechanics, NASA Technical Reports, Air Force Technical Reports and the technical reports from National Laboratories. A listing of all documents researched on bolted joints is included at the end of this chapter.

It is commonly believed that adhesive joints in structures can provide higher efficiency than those of mechanical joints. However, there are many reasons why mechanical joints will continue to be used as long as assembly is needed in a structure. Mechanical joints are practical, easy to use, do not require special surface preparation as adhesive joints do, and are timely and cost effective. In some cases, such as joining of thick composite components, mechanically fastened joints are preferred over adhesive joints. Sometimes mechanically fastened joints are required; for instance, in the assembly of demountable components. Battle damage repair, References [1-1 to 1-3], also requires mechanically fastened joints since they cannot use any major equipment that is not accessible in combat conditions.

Mechanical joints generally include bolts, screws and rivets (or pins). Bolts are mainly used in highly loaded structures such as aircraft. Screws are mainly used for joining composites with wood and pins are suitable for assembling temporary structures or structures that do not require high level of load transferring between the components.

Composite aircraft structural components that transfer high level of loads through the joints use bolts extensively. The applications of bolts include wing

structures [1-4], fuselage structures [1-5], tail structures [1-6], and many others [1-7 to 1-11].

Early work on bolted joints in composites was confined to a single bolt (commonly referred to as single-bolted joints) and was based on the assumption that multiple bolts (normally referred to as multiple-bolted joints) may be regarded as being a number of bolts loaded in parallel. Recent studies showed that the stress distribution around a joint in a laminate was influenced by its surrounding joints. Thus, not only the stress concentrations but also the failure modes were different to some extent, for a single-bolted and a multiple-bolted joint in composite structures. The bolted joint problems in composite structures deserve continuing attention and study because their performance and behavior cannot be translated directly from isotropic materials. The stress concentrations in composite structures due to bolted joints could be considerably higher than those in structures with isotropic materials due to composite directional anisotropy. In addition, composite materials are brittle, a condition that can cause catastrophic failure. Tailoring the design in composite structures is frequently needed to create a safe structure while maintaining the objective of reducing structural weight.

In 1980, Godwin and Matthews [1-12] wrote a review paper in the area of strength of single-bolted joint in composite laminates. Their discussion covered material parameters, fastener parameters and design parameters. The majority of the work reviewed was published in the European countries, especially the United Kingdom. In this report, we will discuss the work on single-bolted joints and multiple-bolted joints in laminated composites, including some additional parameters that were not considered in Ref. [1-12]. Moreover, the materials discussed in Reference [1-12] are mostly glass fiber reinforced epoxy or glass fiber with polyester matrix while this report discusses many laminates made of graphite fiber reinforced epoxy matrix that is commonly used in many aircraft structures.

## **1.2 MAJOR PARAMETERS**

Bolted-joints in laminated composites involving non-uniform through-the-thickness stress distributions and failure mechanisms in a progressive manner are complicated issues. The study of this problem can generally be classified into five main aspects. They are: (1) material parameters (2) fastener parameters (3) design

parameters (4) loading parameters and (5) environment parameters. Each parameter includes several aspects that are discussed in the following.

**Material parameters.** This includes fiber type and form (such as unidirectional, particulate, woven fabric, etc.), resin type, fiber volume fraction of a laminate and the physical and chemical properties of the fiber-matrix interface.

**Fastener parameters.** This includes fastener type (bolt, screw, pin, etc.) and material, fastener size and mechanical properties, fastener clamping pressure, fastener-hole tolerance as well as washer size.

**Design parameters.** This includes joint type (such as single lap, double lap, strap joint, etc.), laminate geometry which includes thickness, end distance to hole diameter ratio, side distance to hole diameter ratio, thickness-to-hole diameter ratio, pitch, back pitch, hole pattern (single hole, multiple holes in a row, in parallel or rows and parallels, staggered rows, etc.) and hole size.

**Loading parameters.** This includes the direction of loading: tension (apply pulling forces between two or more loading surfaces), compression (apply pushing forces between two or more loading surfaces), bearing-bypass loading (the load of the fastener can be applied in any direction regardless of the grips), fatigue loading, impulse loading, creep and relaxation, etc.

**Environment parameters.** This includes steady-state testing environment at room temperature, elevated or cryogenic temperature, thermal spiking, moisture content in the laminates, etc.

**Human and machining parameters:** Technicians can cause some errors in drilling holes and in the process of bolt installation. Likewise, machining tools present problems of accuracy and malfunction.

These parameters will be discussed with experimental data in a later section.

### 1.3 JOINT CONFIGURATIONS

The geometry of a typical single-bolted joint is described in Figure 1-1 where:

$e$  = end distance (distance between the hole center and the end of the plate);

$D$  = hole diameter;

$t$  = laminate thickness;

$W$  = laminate width;

$L$  = length of the laminate.

The configuration of a typical multiple-bolted joint is described in Figure 1-2. In addition to the parameters given above, the following definitions are used to describe the joint:

$p$  = pitch (distance between two bolts in a row);

$L_{ij}$  = back pitch (distance between two bolt holes in parallel,  $i$  and  $j$  rows);

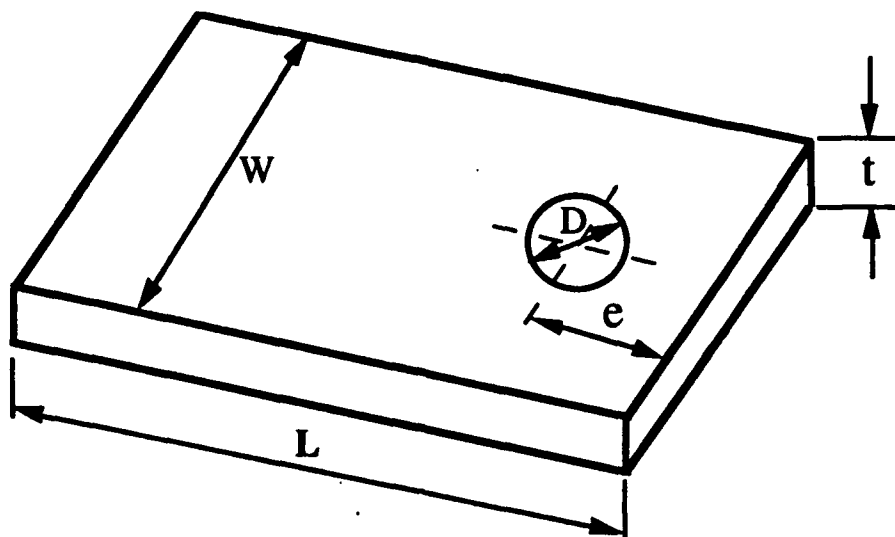
$s$  = side distance (distance between the laminate edge and the first hole center).

These definitions will be used throughout this report. Single-bolted and multiple-bolted joints can be applied in both single lap (shear) and double lap (shear) fashion. Other types of joints can be found in References [1-13] and [1-14].

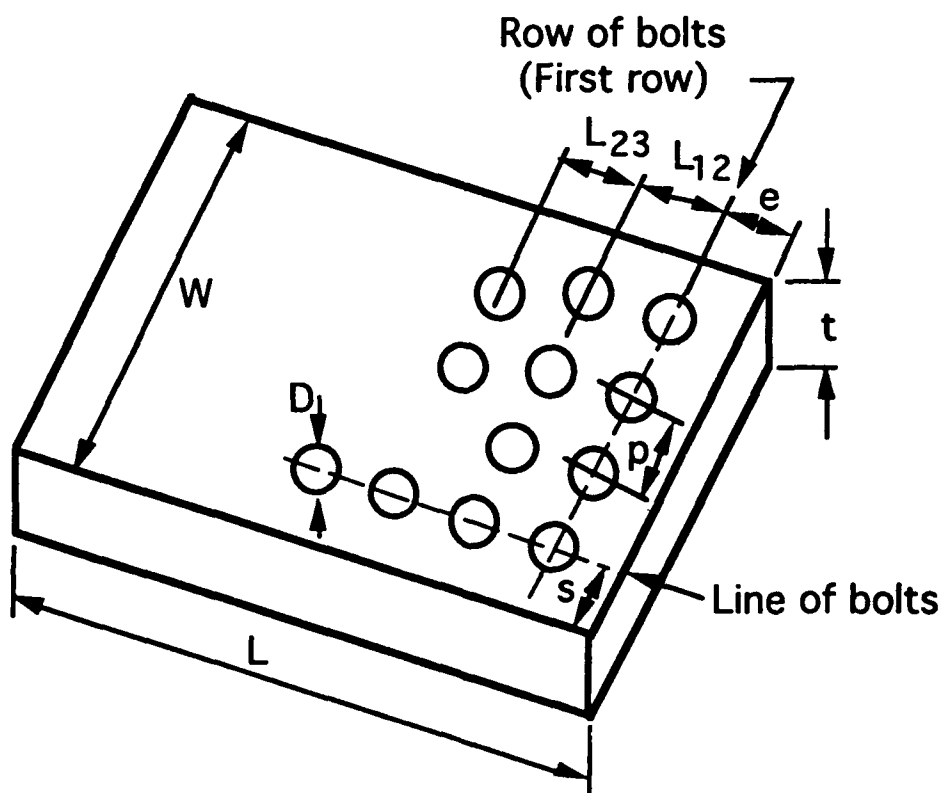
## 1.4 FAILURE MODES

The most basic failure modes of composite laminates with a single-bolted joint loaded in tension include tension, bearing, shear-out and cleavage, Figure 1-3. Another failure mode in composite laminates that is bolt related will be discussed in Fig. 1-7. Under compression loading, the most frequent observed failure modes are compression through the hole and bearing. Generally, failure modes depend on  $e/D$  and  $W/D$  ratios, bolt tightening pressure and washer size as well as the fiber orientations of the laminate. The tension failure mode normally occurs when the  $W/D$  ratio is small. Bearing mode may occur for large  $W/D$  and  $e/D$  ratios (larger than or equal to 4). Shear-out mode is likely to occur when  $e/D$  ratio is smaller than 3. Cleavage is generally associated with bending in a laminate with small end and side distances. Experimental observations have shown that composite laminates often fail in mixed-mode rather than in a simple mode. For instance, any laminate may suffer bearing failure to some degree even if the dominating failure mode is not bearing.

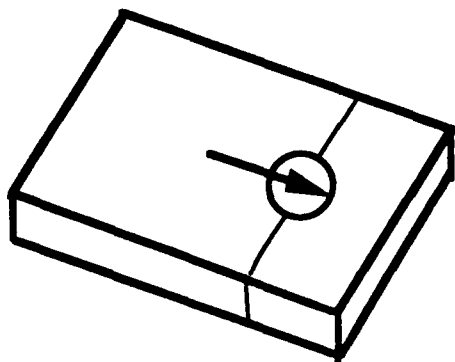
The basic failure modes in composite laminates with multiple-bolted joints are the same as those for single-bolted joints. However, because of the stress interaction between the holes, the global failure mode exhibits some differences from that with a single-bolted joint. In some cases, the dominating failure modes in composite laminates with single-bolted and multiple-bolted joints could be different. Experimental results have shown that tension (or compression) normally



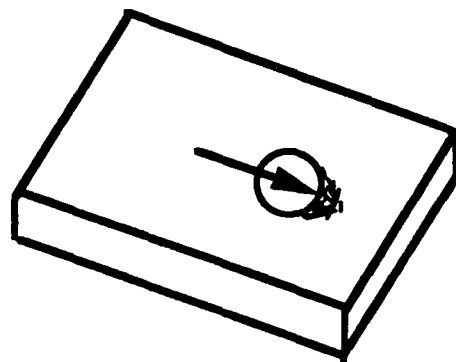
**Figure 1-1. A typical specimen with single-bolted joint.**



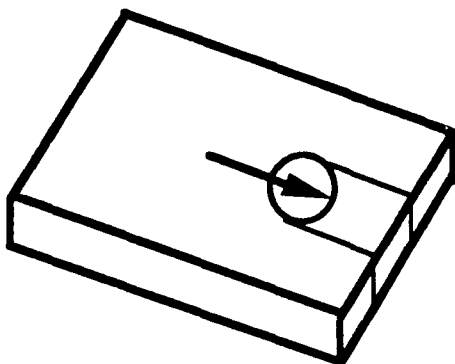
**Figure 1-2. One definition of multiple-bolted joints. Rows 1 and 2 are in uniform rectangular pattern, rows 2 and 3 are staggered.**



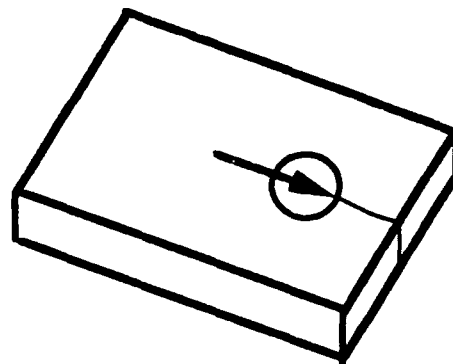
**(a) Tension**



**(b) Bearing**



**(c) Shear-out**



**(d) Cleavage**

**Figure 1-3. Basic in-plane failure modes of bolted joints in laminated composites.**

occurs with or without the accompaniment of other failure modes in composites with multiple-bolted joints. For single-bolted joints, tension may not occur for large W/D ratio.

The influence of the major parameters described in Section 1.2 on the failure modes of composite laminates will be described in a later section.

## **1.5 THE INFLUENCE OF EACH PARAMETER**

The influence of each parameter described in Section 1.2 on the bolted joints of composite laminates will be discussed in the following.

### **1.5.1 Material Parameters**

The discussions of material parameters include the material forms, the effect of hybrid materials and the effect of woven fibers.

#### **1.5.1.1 Material Form**

Aircraft and aerospace grade polymeric composites are normally made from unidirectional prepreg with either graphite or glass fiber to produce laminates of graphite fiber reinforced epoxy (Gr/Ep) or glass fiber reinforced epoxy (Gl/Ep). Kevlar fiber may also be used to produce laminates of Kevlar fiber reinforced epoxy (Ke/Ep).

Ground transportation and structural grades of polymeric composites are normally made from different matrix materials than those for aircraft structures. Glass fiber is often used with polyester and polyurethane to produce laminates of glass fiber reinforced polyester (Gl/Pe) or glass fiber reinforced polyurethane (Gl/Pu).

The fibers used in aircraft and ground structures normally have different forms. Those used in aircraft structures usually are unidirectional whereas those used in ground structures are normally either in random or in woven form. On the other hand, some of those used on water, such as boats, are frequently in chopped form. The influences of bearing strength due to hybrid materials and woven fibers are discussed in the following subsections.

### 1.5.1.2 Effect of Hybrid Material

The European countries have studied extensively the bolted joint problem with Gl/Ep and Gl/Pe laminates rather than Gr/Ep. Many experiments were conducted in the 1960's and early 1970's [1-15]. The bearing strength of laminated composites are in the order of  $Gr/Ep > Gl/Ep > Gl/Pe$  as shown in Figure 1-4. Some investigators have also studied the bolted joints of hybrid composites with Gl/Ep and Gr/Ep prepregs [1-16, 1-17]. The results show that hybrid composites do not improve the bearing strength [1-16], Figure 1-5. However, they show less brittle failure characteristic in contrast to all-carbon laminates. It also appears that 20% of reduction in bearing strength is compensated with a cost saving because of using Gl/Ep rather than all Gr/Ep composites.

### 1.5.1.3 Effect of Woven Fibers

Experimental results on bolt bearing in woven laminates is extremely limited. From the work of Matthews [1-18], we find that the bearing strength of woven laminates generally follows the same trend as those with continuous straight fibers. However, we believe that their failure sequence and damage modes will be different.

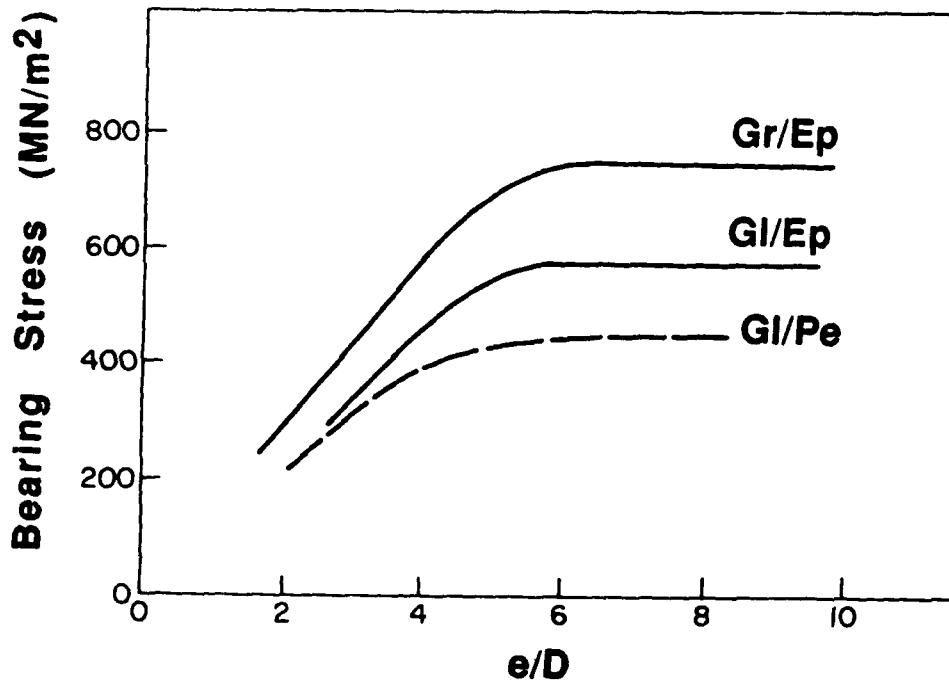
## 1.5.2 Fastener Parameters

Mechanical fastened joints can generally be classified into three kinds: screws, rivets and bolts for nonmetallic materials.

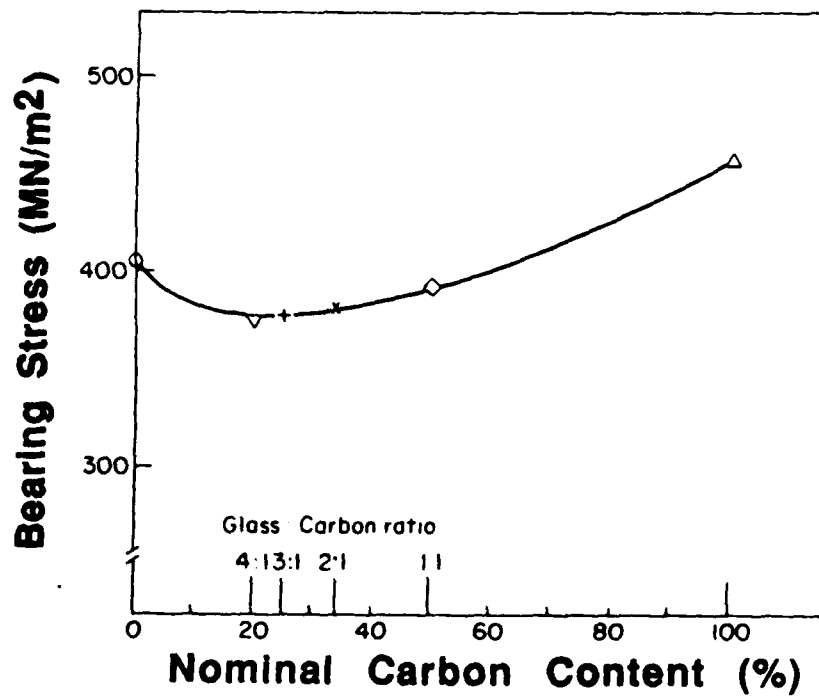
### 1.5.2.1 Characteristics of Mechanical Fastener Joints

**Screw Joints.** Among the three kinds of mechanical fastener joints, *screws* offer the lowest load-carrying capability. They often cause damage to the laminates in the process of being installed. Therefore, the applications of screws have been limited to joining composites with woods in most cases. One exception is the self-tapping titanium screw [1-19], developed by Kaynar (Figure 1-6), which has been used as an anti-peel fastener for the adhesive-bonded stiffeners of the Tomahawk composite wing. Screw joints of Gl/Pe laminates were reported in SPI handbook [1-20].

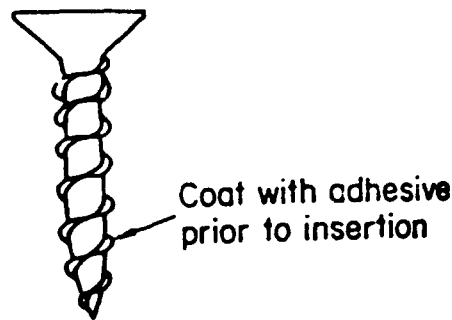
**Rivet Joints.** Rivet joints were used much more often in metals than in polymeric composites. The laminates being joined by rivets are generally thinner



**Figure 1-4. Bearing strength with  $e/D$  ratio of a cross-ply laminate of Gr/Ep, Gl/Ep and Gl/Pe [1-16].**



**Figure 1-5. Bearing strength of hybrid composites with varying glass:carbon ratio.**



**Figure 1-6. Self-tapping screw.**

than 3 mm (0.118 in). The riveting operation can be performed much faster than the other two joining methods. However, it is done in a way similar to impact loading of a laminate. Delamination and split out on the backside from the impact forces as well as some other local damage can be formed around the rivet hole. Due to the nature of the riveting process by rivet guns, the closing force is not readily controlled. Because of the potential problems they might cause, rivet joints in composite structures are not recommended. More discussion of riveted joints in Gr/Pe composites is given by Rufolo [1-21].

**Bolted joints.** Bolted joints offer the greatest load-carrying capability in composites among the mechanical fastener methods. The holes are drilled in a separate process from the installation. If the holes are prepared carefully and with appropriate machining tools, no damage will be caused to the composite structures. This should be emphasized as critical and is a manufacturing science in itself. The drawback is that the cost is the highest among the three kinds of mechanical fasteners. During the past two decades, considerable numbers of studies have been done in the area of bolted joints of laminated composites. Bolted joints are perhaps the best method for joining demountable components of aircraft and aerospace structures. Washers are normally used with bolted joints. Their function is to spread the tightening pressure more evenly and over a bigger area. The significance of applying tightening pressure through the bolts and washers will be discussed in a later section.

**Special Fasteners.** Fasteners other than the above three basic kinds are referred to as special fasteners. Special fasteners include Hi-Lok, Bigfoots, semi-tubular rivets, Cherry Buck rivet, stress-wave rivet system, groove proportioned lockbolt (GPL), composite fasteners and self-tapping screw. All these special fasteners were designed for use in composite structures. The GPL fastener system is an all-titanium permanent fastener. The primary advantages of the composite fasteners [1-22] are total galvanic compatibility, low cost and high stiffness-to-weight ratio.

### 1.5.2.2 Fastener Problems

There are four primary problems associated with bolted composite joints. These are galvanic corrosion, galling, installation damage and low pull-through strength.

**Galvanic corrosion.** The basic driving force of the galvanic corrosion reaction is the difference in electrode potential between the Gr/Ep and the metals [1-23]. Prince [1-23] suggested the use of protective coatings to protect against galvanic corrosion. He concluded that this method did not work when flaws exist. A comparison of galvanic compatibility between fasteners and composite materials is listed in Table 1-1 [1-24].

**Galling.** This problem often occurs during the installation of some threaded fasteners in composite joints. One example is the application of titanium or A286 nuts with high prevailing torque titanium fasteners (e. g., Hi-Lok). The nuts and the fasteners tended to lock-up during installation, before the desired pre load was applied.

**Installation damage.** Forcing fasteners into an interference-fit hole of a laminate can cause the plies in the backside to delaminate. This is not to imply that interference-fit is harmful to composite structures. Limited experimental data have shown that joint strength of composite structures can be improved with interference. In the process of most rivet installation, the hole is completely filled by the shank expansion. This operation also creates interference-fit and it causes delamination and ply buckling for Gl/Ep laminates. The damage caused by interference-fit can be reduced or eliminated if appropriate fasteners are used. For instance, this problem can be overcome using the Stress-Wave rivet system and a Rivnut developed by Goodyear (both are not popular). Another kind of damage that can easily be formed is due to impact forces in installation. One example is

**Table 1-1. Comparison of galvanic potential of fastener materials with composites.**

<b>Fastener Material</b>	<b>Compatibility with Gr/Ep Composites</b>
A286	Acceptable
Aluminum	Not compatible
Cadmium	Not compatible
Chrom. plate	Adequate with A286, PH13-8MO
INCO 600 (Cobalt alloys)	Good
Low alloy steel	Not compatible
Magnesium alloys	Not compatible
Martensitic stainless steel	Not compatible
Monel	Marginal
MP-35N (Nickel)	Good
PH13-8MO (Molybdenum alloys)	Acceptable
Silver plate	Adequate with A286, PH13-8MO
Titanium and its alloys	Very good
Zinc plate	Not compatible

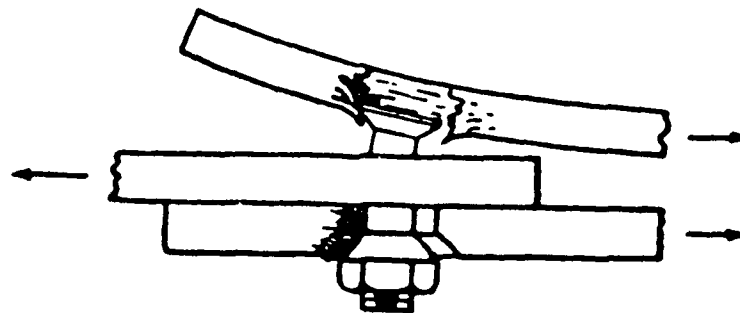
the use of a conventional riveting gun. Delamination, fiber-matrix splitting and fiber breakage may be formed on the backside of the hole.

**Low pull-through strength.** It is well known that composite structures have low pull-through strength. The failure mode is illustrated in Figure 1-7 [1-25]. One remedy to this problem is to use fasteners with enlarged footprints and enlarged heads.

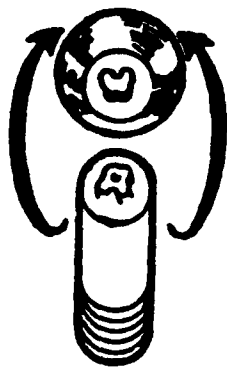
### 1.5.2.3 Fastener Materials and Failure Modes

Metal fasteners are commonly made of steel, titanium or aluminum. Their tensile moduli are 30, 16 and 10 msi, respectively. The range for tensile strengths of steel and titanium bolts is approximately 220 to 160 ksi. The test data of Reference [1-25] show that the steel fasteners result in slightly higher gross strengths compared to titanium fasteners. However, the incompatibility of the galvanic potential between the uncoated steel and the graphite/epoxy materials [1-23] suggests that galvanic corrosion will be a potentially serious problem. Therefore, titanium fasteners are commonly recommended because of their galvanic compatibility with graphite/epoxy materials. The galling problem caused by titanium fasteners and A286 nuts in the situation of high prevailing torque can be solved with proper design of the fastener system.

In some cases, bolt failure was observed before the composite structures failed [1-25]. The basic failure modes of the bolts include: (1) the neck (juncture of head and shank) fails in tension and (2) shank fails in shear, Figure 1-8.



**Figure 1-7. Failure mode of bolt pulling through laminate.**

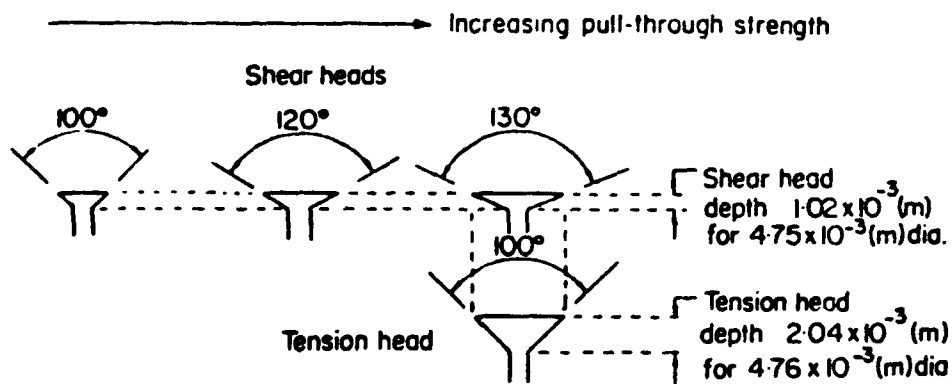


(a) Tension failure



(b) Shear failure

**Figure 1-8. Bolt failure modes.**



**Figure 1-9. Countersink tension head and shear head design.**

#### **1.5.2.4 Effect of Fastener Head and Countersink Angle**

The head designs of the bolts include protruded, tension and shear configuration. The depth of a tension head is twice that of a shear head, Figure 1-9. Ramkumar and Tossavainen [1-25] demonstrated that protruded head fasteners yield higher bearing strengths compared to flush head fasteners (up to 23% difference). Because of aerodynamic stability, flush head fasteners need to be used to maintain flush outer surfaces on a structure. Cole et al. [1-19] demonstrated that 100° tension head fastener joints yield higher laminate bearing strengths compared to 100° shear head fastener joints under static loading. They also found from fatigue tests that the 100° tension flush-head is the best configuration for strength and durability as opposed to the 100°, 120° or 130° shear flush configurations. The minimum head thickness for 100° countersink was recommended by Dastin [1-14] for fastener diameters ranging from 2.38 mm (3/32 in) to 9.52 mm (3/8 in).

#### **1.5.2.5 Effect of Interference-Fit and Bolt Clearance**

Garbo and Ogonowski (1981) [1-26] conducted an experiment using Gr/Ep (AS1/3501-6) [45/0/-45/0/90/0/45/0/-45/0]s (50/40/10) and [45/0/-45/0/45/90/-45/0/±45]s (30/60/10) laminates with 0.003 and 0.008 in of interference-fit. They concluded that these laminates are insensitive to these interference-values at room temperature dry conditions. At elevated temperature wet (ETW) conditions (250° F and approximately 0.9-1.0% moisture by weigh) the joint strength of the first laminate was increased by 8-15% at both levels of interference. The change in the joint strength for the second laminate ranged from -1.8 to 4.6% at the ETW condition. Other people claimed that interference-fit can improve the fatigue life of composite structures.

Rowlands et al. [1-27] showed that bolt clearance has significant effects on the radial stress distribution of wood. The radial stress component,  $\sigma_r$ , can be reduced by as much as five times when the bolt/hole ratio increases from 0.824 to 0.988. Since no test data were provided, the effect of bolt clearance on the bearing strength is not clear.

### **1.5.3 Design Parameters**

The bolted-joint strengths of laminated composites are affected by many parameters from the designer point of view. The effect of each parameter will be

discussed separately in the following.

### **1.5.3.1 Effect of Clamping Pressure**

An increase in the fastener torque increases the friction between the structural components, and increases the rotational constraint of the fasteners. This lateral constraint prevents the delamination and ply buckling failure modes under the washer area. It also changes the failure mode around the joint area. Stockdale and Matthews [1-28], Collings [1-29], Collings [1-30] (Figure 1-10), Kretsis and Matthews [1-31] (Figure 1-11) and Godwin et al. [1-39] all show that clamping pressure can significantly increase the bearing strength of Gr/Ep, Gl/Ep and Gl/Pe laminates with single-bolted joints. In fact, even the restraint offered by a finger-tight bolt and nut can improve the bearing strength considerably [1-12] compared to a pin-loaded hole. Ramkumar and Tossavainen [1-25] show that fastener torque only has little effect under tensile loading. However, under compressive loading, the bearing strength increases by approximately 30% when the fastener torque is increased from 0 to 200 in-lbs.

The improvement of the bearing strength due to the lateral restraint could be explained by the change in laminate failure mode. Crews [1-32] reported that the failure mode is bearing under pin bearing condition. Under a moderate clampup condition, the failure mode is shearout under the washer and bearing outside the washer area. In the case of a high clampup condition, a mixed-mode of tension and shearout occur under the washer and bearing outside the washer area.

Beyond a certain value of clamping pressure only little increase in bearing strength is obtained. This value depends on the material system and laminate layup. It ranges from 15 MPa [1-31] for Gl/Ep  $[0/\pm 45]_{2s}$ , 22 MPa for Gr/Ep [1-30] to over 90 MPa [1-28] for Gl/Ep. It is noted, however, that at a much higher clamping load compressive damage could be done by washers or fastener heads digging into the laminate.

### **1.5.3.2 Effect of Joint Eccentricity**

Joint eccentricity (bending) can be produced by single lap tests. The significance of this effect can be studied by comparing single lap test results with double lap test results. The tests with Gr/Ep (AS1/3501-6)  $[(45/0/-45/0)_2/0/90]_s$ ,  $[45/0/-45/0_3/90/0_3]_s$  and  $[45/0/-45/0/45/90/-45/0/45/-45]_s$  laminates [1-25] reveal that the bearing strength of the first two are relatively unaffected by the change of a

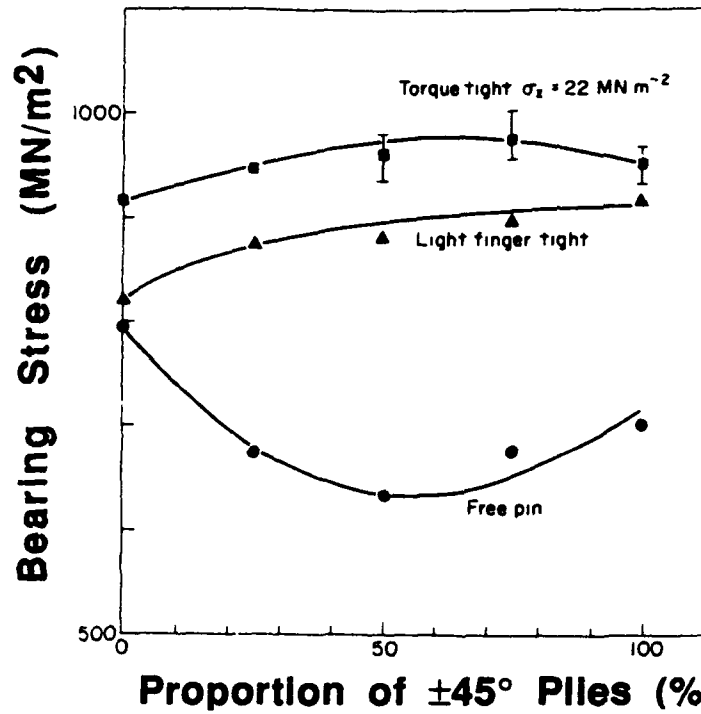


Figure 1-10. Effect of bolt tightening pressure on the bearing strength (double lap) of Gr/Ep HTS/914  $[0_m/\pm 45_n]_s$  laminates.  $D=6.35 \text{ mm}$  (0.25"),  $W=50 \text{ mm}$  (1.97")

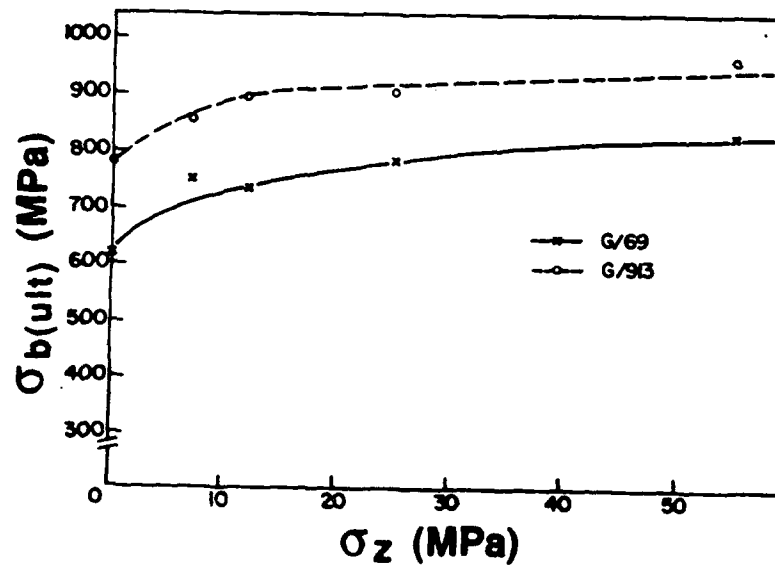


Figure 1-11. Effect of bolt clamping pressure on the bearing strength (double lap) of G/Ep  $[0/\pm 45]_{2s}$  laminates.  $D=6.35 \text{ mm}$  (0.25"),  $t=3 \text{ mm}$  (0.12").

single shear to a symmetric double shear test configuration. The third one reveals 19% higher bearing strength using a symmetric double shear test configuration. The eccentricity effect is more pronounced under compressive loading. Even the first laminate shows 20% difference in bearing strength.

### 1.5.3.3 Effect of W/D Ratio

Collings [1-30], Kretsis and Matthews [1-31] as well as Ramkumar and Tossavainen [1-25] showed that joint strength can be improved significantly by an increase in the W/D ratio (Plate Width/Hole Diameter). Kretsis and Matthews further pointed out that the failure mode changes from tension to bearing at W/D ratio equal to about 3.2 for GI/Ep  $[0/\pm 45]_{2S}$  and about 6 for GI/Ep  $[\pm 45]_{3S}$ , Figure 1-12. Collings showed that the change of failure mode occurs within the same range of W/D ratios for Gr/Ep. Matthews et al. [1-16] showed that the failure modes change (tension to bearing) at  $W/D = 3$  for all cross-ply laminates made of all-carbon, all-glass and glass/carbon hybrid reinforced XD-927 epoxy systems. Ramkumar and Tossavainen showed that the bearing strength of a laminate remains relatively unchanged for  $W/D > 6$ . When  $W/D \leq 4$  the failure mode is net section failure across the hole. For  $W/D > 4$  the failure mode is primary shear-

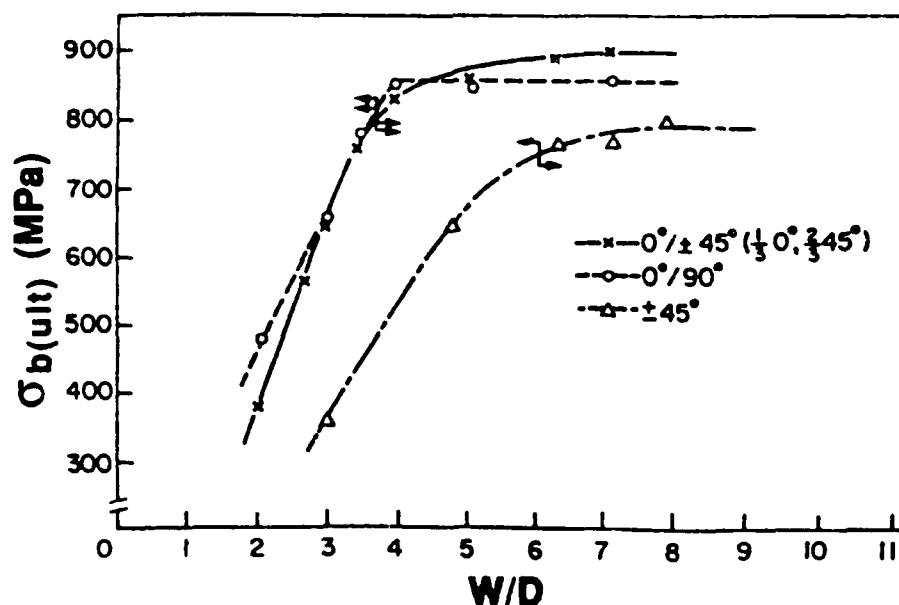


Figure 1-12. Effect of W/D ratio on the bearing strength of GI/913 laminates.  $D=6.35$  mm (0.25"),  $t=3$  mm (0.12"), clamping pressure=12 MPa.

out if the  $e/D$  is not large enough to create a bearing failure. All these results seem to suggest that the  $W/D$  value for the mode changeover point is larger for a matrix dominated laminate than that for a fiber dominated laminate.

#### 1.5.3.4 Effect of $e/D$ Ratio

The work of Collings [1-29], Kretsis and Matthews [1-31] and Ramkumar and Tossavainen [1-25] all showed that the failure mode of  $GI/Ep$  (former two Ref.) and  $Gr/Ep$  (latter Ref.) laminates changes from shear to bearing by increasing the  $e/D$  ratio (end distance/hole diameter) to some critical value. Increasing the  $e/D$  ratio also improves the joint strengths of the laminates. Kretsis and Matthews showed that the change of failure mode took place at  $e/D$  equal to 3 for  $GI/Ep$   $[\pm 45]_{3s}$  laminate and about 4.5 for  $GI/Ep$   $[0/90]_{3s}$ , Figure 1-13. Thus, the value of  $e/D$  for the change of failure mode is highly dependent on the laminate layup. Apparently, the first layup is more shear resistant than the second one. The value of  $e/D$  for the change of failure mode seems to change only slightly for different material systems, Figure 1-14 [1-31]. Moreover, the variation of the bearing strength versus the  $e/D$  ratio is more gradual for  $GI/Ep$  than for  $Gr/Ep$  laminates.

#### 1.5.3.5 Effect of $D/t$ Ratio

Kretsis and Matthews [1-31] have tested the bearing strength of  $GI/Ep$   $[0/\pm 45]_{2s}$  laminates with various hole diameters under the restraint condition of a finger-tight bolt. They concluded that bearing strength decreases significantly as  $D/t$  ratio (hole diameter/plate thickness) increases, Figure 1-15. The reason is that a large  $D/t$  ratio tends to cause out-of-plane buckling in the laminates. Figure 1-15 and the hybrid data [1-16] both show that the bearing strength has a linear relationship with  $D/t$  ratios between 1 and 3. For  $D/t > 3$ , the slope increases creating a nonlinear relationship. Oleesky and Mohr [1-20] suggested that full bearing strength is less likely to be developed if  $D/t > 1$ . Other researchers [1-12] show that the bearing strength is independent of the  $D/t$  ratio when sufficient lateral constraint is applied on the bolts.

#### 1.5.3.6 Effect of Stacking Sequence

The experimental results of Quinn and Matthews [1-33] and Smith and Pascoe [1-34] suggest that stacking sequence has significant effect on pin-bearing strength of  $GI/Ep$  laminates [1-33] but has little effect for  $Gr/Ep$  laminates [1-34]. However, it must be noted that the  $[90/\pm 45/0]_s$  layup had the highest bearing

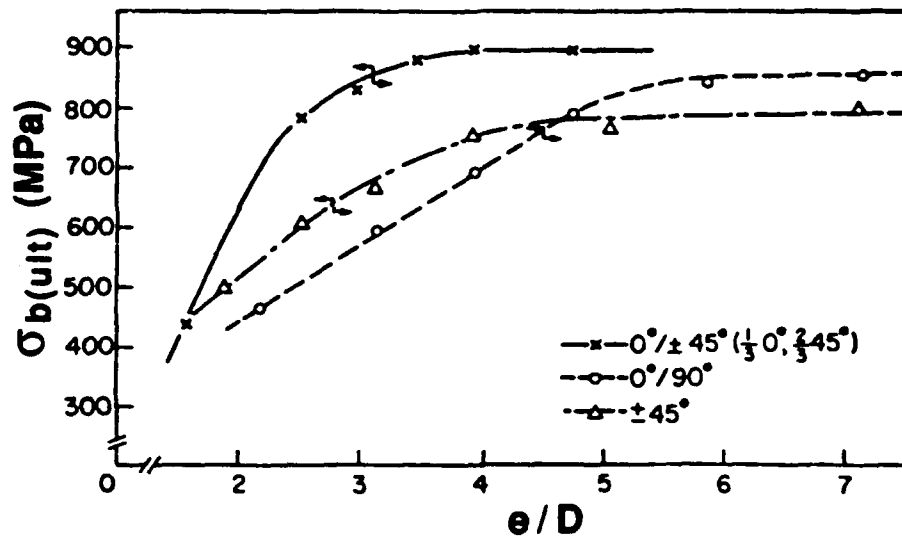


Figure 1-13. Effect of  $e/D$  ratio on the bearing strength of G/913 laminates.  $D=6.35$  mm (0.25"),  $t=3$  mm (0.12"), clamping pressure=12 MPa.

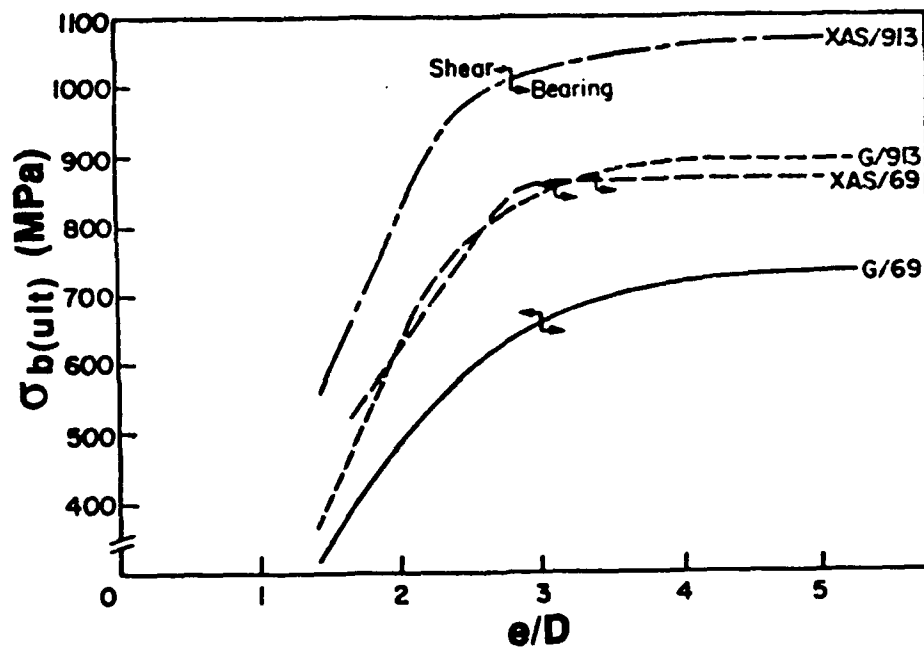


Figure 1-14. Effect of  $e/D$  ratio on the bearing strength of  $[0/\pm 45]_{2s}$  laminates.  $D=6.35$  mm (0.25"),  $t=3$  mm (0.12"), clamping pressure=12 MPa.

strength for the Gl/Ep material system [1-33], and this layup was not tested for the Gr/Ep system [1-34]. The former authors [1-33] showed that placing the 90° layer at or near the laminate surface increases the bearing strength of Gl/Ep laminates, Figure 1-16. According to the data in Ref. [1-34], the stacking sequence effect on the bearing strength of Gr/Ep laminates is eliminated as the clamp-up torque is increased to 20 in-lb. The value of clamping pressure that creates the same effect for Gl/Ep laminates is unknown currently. It has been shown that the stacking sequence changes the failure mode and the failure sequence due to the difference in stress distribution. Some of this phenomenon can be qualitatively explained by the interlaminar normal stress [1-34].

Grouping together plies with the same orientation can cause a reduction in the bearing strength. The study by Ramkumar and Tossavainen [1-25] concluded that the reduction in bearing strength is approximately 7%, 10% and 5%, respectively, for three different stacking sequences of Gr/Ep (AS1/3501-6)  $[(45/0/-45/0)_2/0/90]_S$ ,  $[45/0/-45/0_3/90/0_3]_S$  and  $[45/0/-45/0/45/90/-45/0/45/-45]_S$  laminates.

#### **1.5.3.7 Effect of Multiple-Bolted Joints**

In practice, multiple-bolted joints are of great importance. Within a multiple-bolted joint, fastener holes normally are subjected to the combined effects of bearing loads and bypass loads. One must be very careful in using single-bolted joint data to design structures with multiple-bolted data. Abundant data in the literature have shown that single-bolted joint data are not directly translatable into multiple-bolted data. This is understandable because of the stress interaction between the bolt holes. The stress field of each bolt hole is influenced by the surrounding bolt holes, which cause a weakening effect. This interaction becomes increasingly significant as the hole distance is reduced.

Multiple-bolted joints can change the failure mode of a laminate as compared to a single-bolted joint. Pyner and Matthews [1-35] have shown that a Gl/Ep  $[-45/0]_{2S}$  laminate with a single-bolted joint failed in tension and shearout modes under tension loading. It changed to a purely tension mode for a joint consisting of four bolts in a line. This phenomenon can be explained by the result of the stress analysis performed by Ramkumar et al. [1-36]. The loads are not uniformly distributed among the four bolts. Instead, the distribution is quite different from one bolt to another. The ratios for five bolts in a line are 0.164:0.124:0.161:0.207:0.345 as shown in Figure 1-17. Ramkumar and Tossavainen [1-37] and Garbo et al. [1-38]

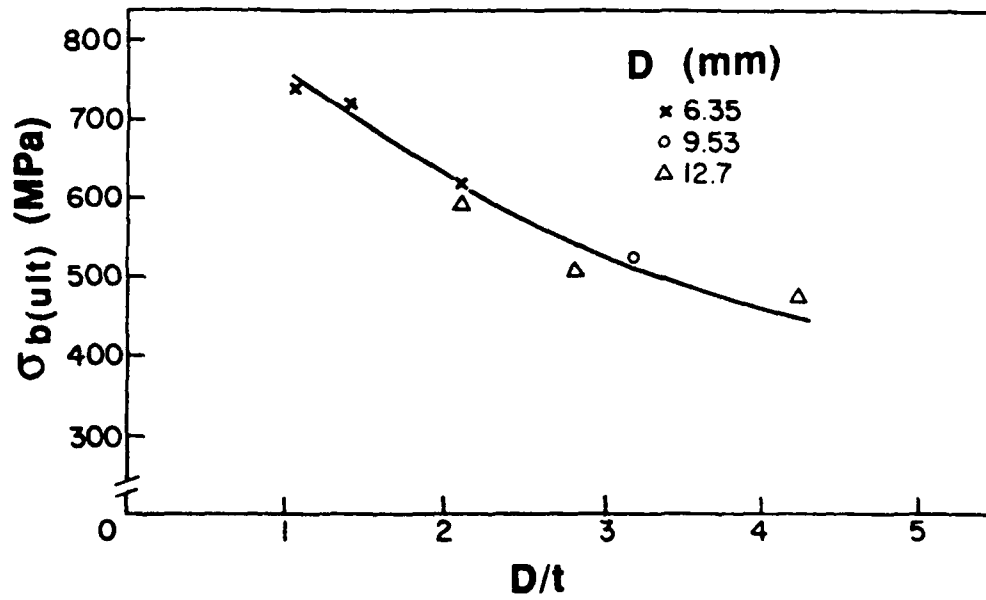


Figure 1-15. Effect of D/t ratio on the bearing strength of G/69  $[0\pm45]_2s$  laminates.  $t = 3, 4.5$  or  $6$  mm ( $0.12, 0.18$  and  $0.24$  in.), finger-tight bolt.

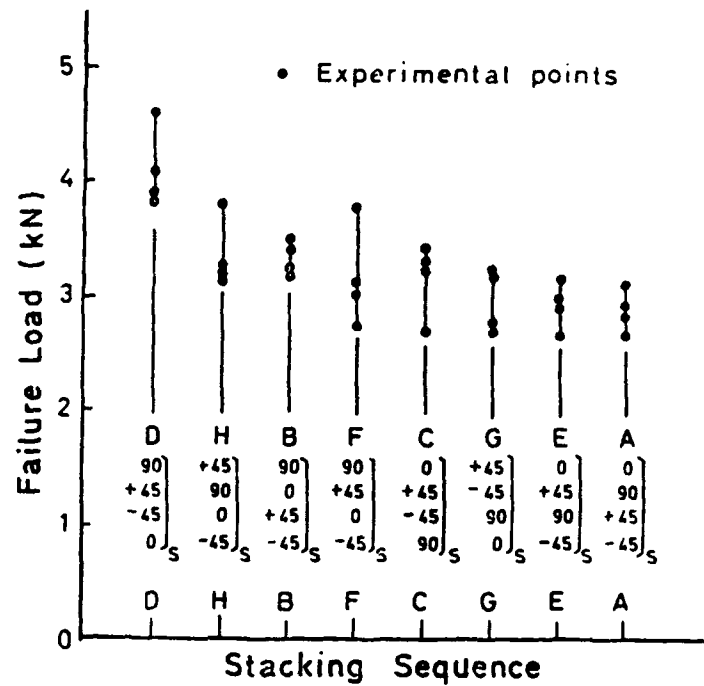


Figure 1-16. Effect of stacking sequence on failure load of G/Ep laminates.

have conducted a significant number of static tests on multiple-bolted joints using Gr/Ep laminates. Godwin et al. [1-39] and Chang et al. [1-40] have also conducted static tests on multiple-bolted joints using Gr/Ep and Gl/Pe laminates, respectively.

### 1.5.3.8 Effect of Staggered Rows of Fasteners

Godwin et al. [1-39] demonstrated that no substantial improvement in bearing strength was gained by using staggered rows of fasteners. However, the use of

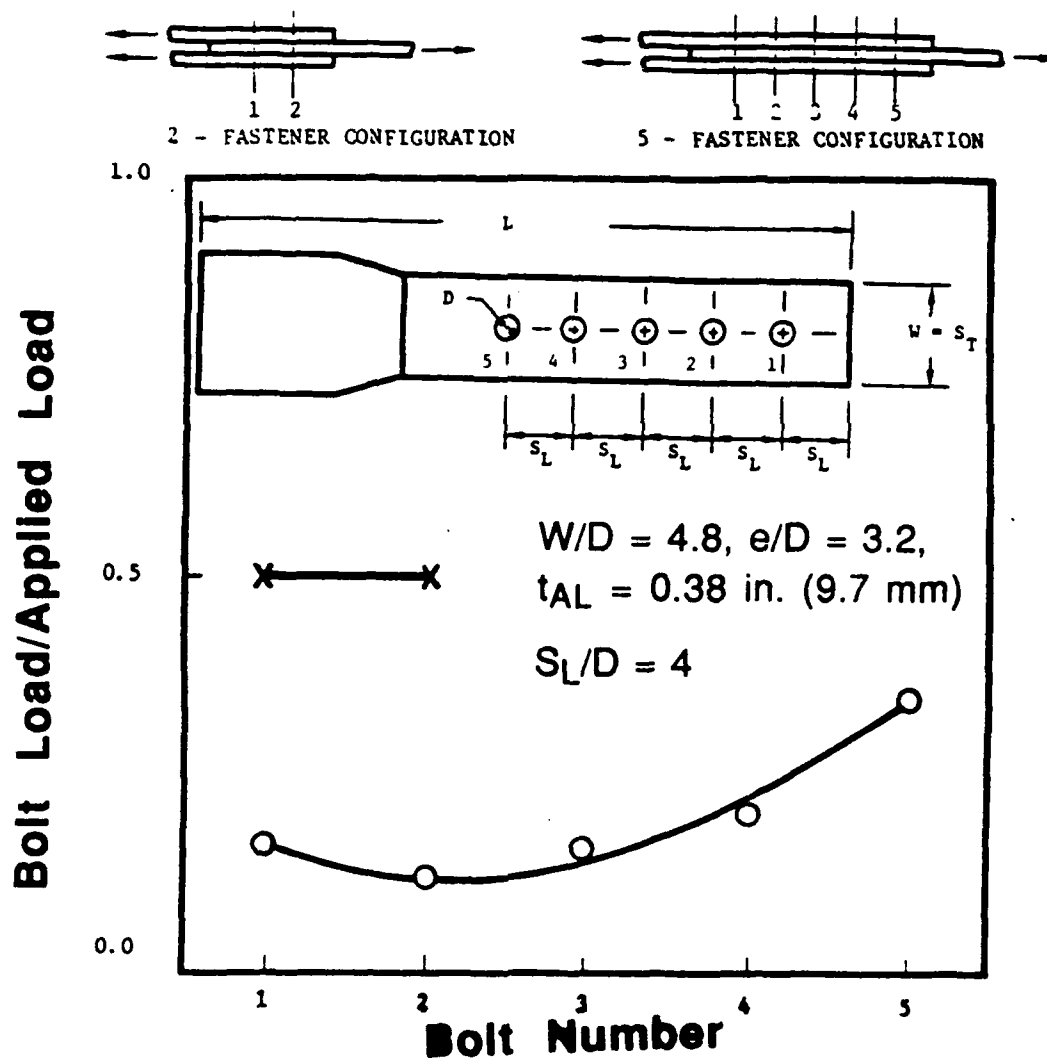


Figure 1-17. Fastener load distribution in AS1/3501-6 50/40/10 (% of 0,  $\pm 45$  and  $90^\circ$  plies) laminates (Double-lap joint, bolt diameter=5/16 in., protruding head steel bolt torqued to 100 in-lb, room temperature dry condition).

staggered rows of fasteners creates a larger damaged area as compared to a single row of fasteners. This suggests that the design of a staggered row of fasteners can absorb more energy than a single row of fasteners does. In practice, however, a rectangular fastener pattern is more commonly used than staggered rows.

### 1.5.4 Effect of Loading Parameters

Loading parameters include static tension, static compression, static bearing-bypass loading and fatigue loading. All the testing results mentioned above were conducted under static tension or static compression loading conditions. The bearing-bypass loading and fatigue loading will be discussed in the following.

#### 1.5.4.1 Effect of Bearing and Bypass Loads

In many practical cases, fastener holes are subjected to the combined effects of bearing loads and loads that bypass the hole to be reacted elsewhere in the joint. The portion that bypasses the hole is defined as bypass load. Any bearing-bypass testing requires an apparatus that can apply bearing and bypass loadings simultaneously. Very little experimental data are available in this area.

Three approaches have been reported in the literature for bearing-bypass testing in composite laminates. The first approach uses levers and linkages to divide the applied load into two proportional parts [1-41]. The second approach uses a "scissor" mechanism to apply a bearing load between two holes in the test specimen [1-42]. This bearing load is held constant while the bypass load is varied. The third approach uses two servo-control systems. One controls the bearing load while the other controls the bypass load [1-43]. Crews and Naik [1-44] developed a testing apparatus similar to Concannon's [1-43] but simpler in design. They used Gr/Ep (T300/5208) [0/45/90/-45]<sub>2s</sub> laminates to show that clearance fit created a nonlinear relationship between the bearing and the contact angle. Naik and Crews [1-45] have reported the fracture strength of Gr/Ep T300/5208 laminates under several combinations of bearing-bypass load ratios ( $\pm 0$ ,  $\pm 1$ ,  $\pm 3$  and  $\pm \infty$ ). They found that bearing and bypass strength in the tension quadrant form a linear interaction, Figure 1-18, which agrees with the observation by Smith [1-17].

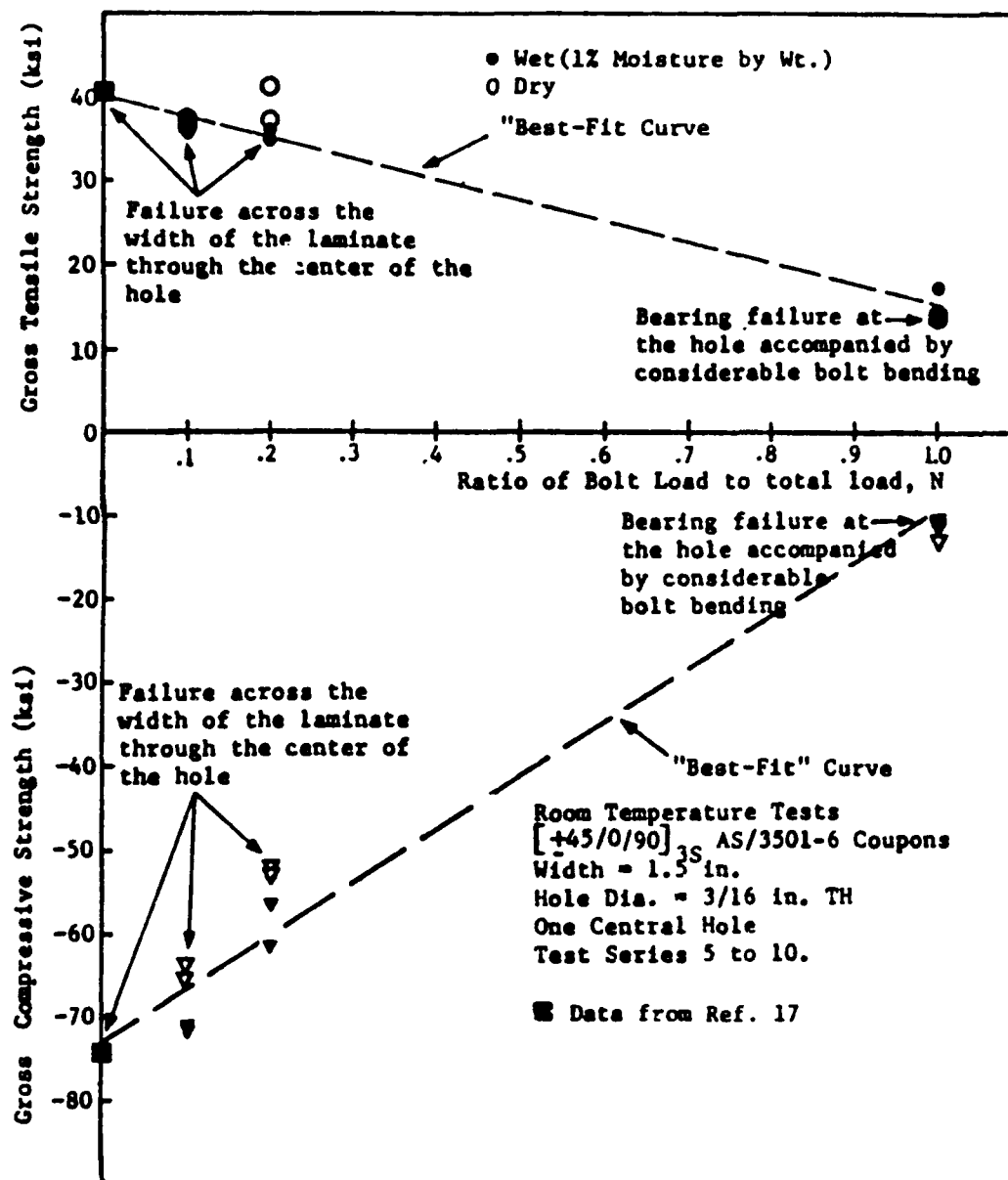
Ramkumar [1-41] showed that the gross tensile and gross compressive strengths are linearly proportional to N (the ratio of the bolt load to the total applied load) for a AS1/3501-6 [ $\pm 45/0/90$ ]<sub>3s</sub> laminate, Figure 1-19. This relationship is interesting because it involves a change of failure mode from net section to bearing. Additional study is needed for an in-depth explanation of this kind of relationship.

#### 1.5.4.2 Effect of Fatigue Loading

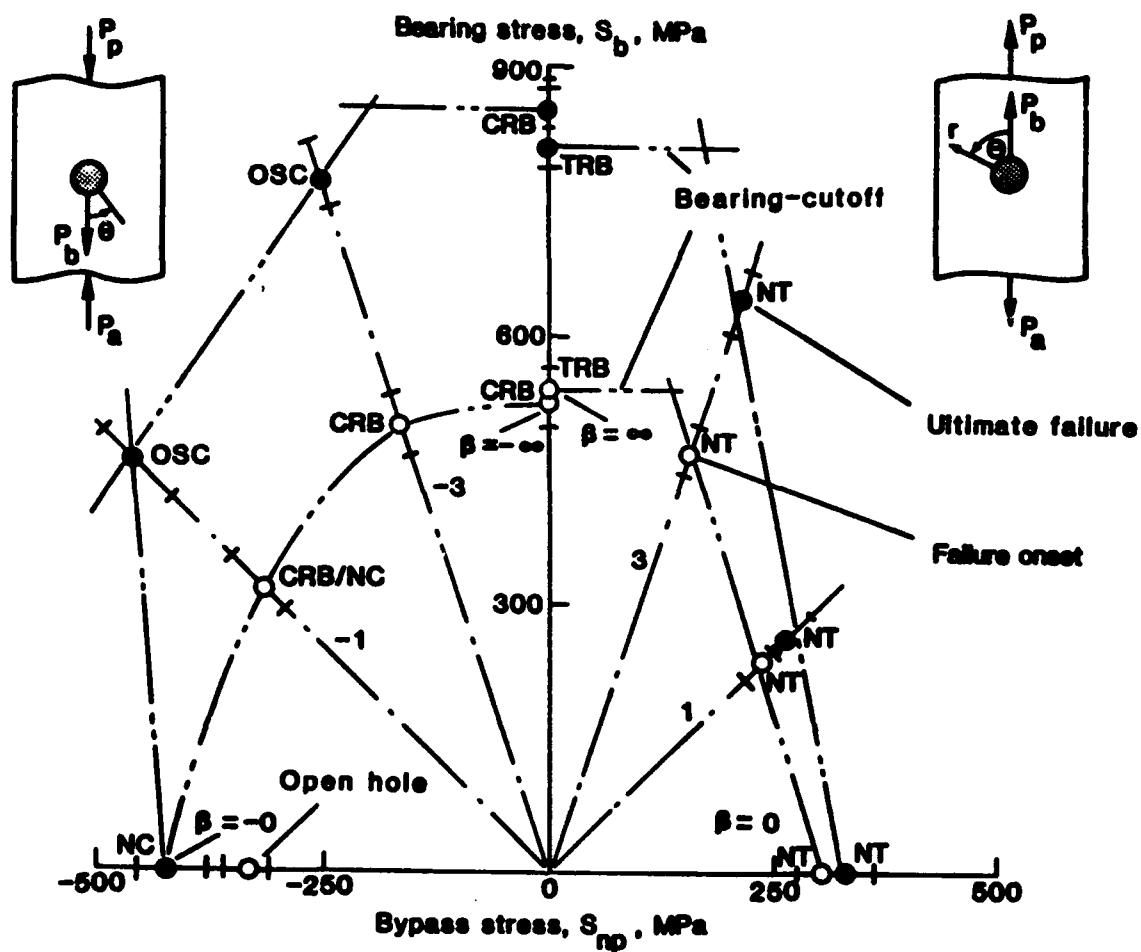
Very few papers have been published in the area of fatigue of bolted joints in composite laminates. Crews [1-46] has studied T300/5208 [0/45/90/-45]<sub>2s</sub> laminates under bolt bearing loads for a range of bolt clampup torque and three environmental conditions including water. His result showed that high clampup torque improved both the static and fatigue limit by about 100% compared to a pin-bearing case. He also found that tests in water degraded static bearing strength slightly, but reduced the fatigue limit about 40% below that obtained in air.

Ramkumar [1-25] shows that for tension-tension fatigue loading, no fatigue failures were induced (for a million cycles) in AS1/3501-6 [(45/0/-45/0)<sub>2</sub>/0/90]<sub>s</sub> laminates when the maximum cyclic bearing stresses are below 90% of the static bearing strength. For compression-compression fatigue, the laminate does not suffer any fatigue failure if the maximum cyclic bearing stresses are below 85% of the static bearing strength. For tension-compression fatigue, fatigue failures will occur if the maximum cyclic bearing stress value is above 35% of the static bearing strength.

From the test results of Ramkumar and Tossavainen [1-25], it is quite important to note that when 100° tension flush-head steel fasteners were used, four out of nine tests resulted in fastener failures. When titanium fasteners were used instead of steel, fastener failures occurred in every case. As opposed to static loading tests, this result reveals that graphite/epoxy composite is much more fatigue resistant than metals.



**Figure 1-18. The interaction of the bearing-bypass strength of Gr/Ep T300/5208 [0/45/90/-45]<sub>2S</sub> laminates.**



where

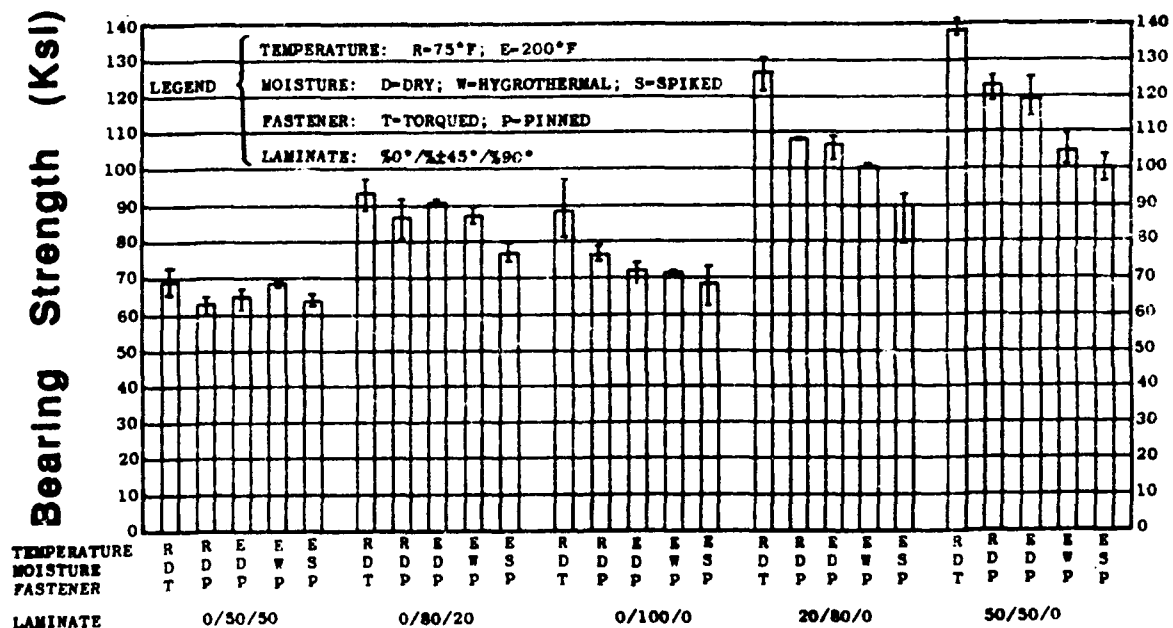
NT: net-section tension,  
 TRB: tension-reacted bearing,  
 CRB: compression reacted bearing,  
 NC: net-section compression,  
 OSC: offset-compression.

**Figure 1-19. Gross tensile strength versus bolt load/total load for Gr/Ep AS1/3501-6 [ $\pm 45/0/90$ ]<sub>3s</sub> laminates.**

### 1.5.5 Environmental Parameters

In 1977, Wilkins [1-47] tested and reported that pin-bearing strengths of many Gr/Ep T300/5208 laminates (especially those containing  $\pm 45^\circ$  and  $90^\circ$  layers) were not affected by moisture content up to 1.48% at room temperature and at elevated temperatures up to  $200^\circ\text{F}$ . Those laminates that contain  $0^\circ$  layers are most affected, as shown in Figure 1-20. For instance, the pin-bearing strength of Gr/Ep 50/50/0 (% of 0,  $\pm 45$  and  $90^\circ$  layers) laminates for the  $75^\circ\text{F}$  dry condition is 122.7 ksi. It decreases to 105.1 ksi (14% decrease) after it was soaked 142 days at  $180^\circ\text{F}$  and 98% relative humidity (1.48% weight gain). The bearing strength was further reduced to 100.3 ksi (18% decrease) when it was subjected to 42 heat spikes at  $300^\circ\text{F}$ . Compared with unnotched laminates, Wilkins found that the reduction in fracture strength due to environmental effects was more significant in the case of bolted joints.

Ramkumar and Tossavainen [1-25] studied the Gr/Ep AS1/3501-6  $[(45/0/-45/0)_2/0/90]_S$  (50/40/10),  $[45/0/-45/0_3/90/0_3]_S$  (70/20/10) and  $[45/0/-45/0/45/90/-45/0/45/-45]_S$  (30/60/10) laminates. They showed that the bearing strengths of these



**Figure 1-20. Environmental effects on bearing strength of Gr/Ep T300/5208 laminates.**

laminates were decreased by 8, 12 and 8%, respectively, at 218°F and 1.0% moisture content as compared to room temperature dry conditions. Garbo and Orgonowski [1-26] compared the bearing strengths at room temperature-dry and 250°F-0.9% moisture content conditions. They reported a reduction of 11, 22, 16 and 12% for the T300/5208 30/60/10 and 50/40/10 laminates as well as AS1/3501-6 50/40/10 laminate, respectively.

These results show that hot-wet environmental conditions can cause a reduction in bearing strength up to 16% in most cases. It can increase to 20% or more with thermal spiking.

As opposed to all the results mentioned above, Kim and Whitney [1-48] reported a tremendous reduction in bearing strength of Gr/Ep T300/5208 laminates due to moisture and elevated temperature. They tested  $[0_2/\pm 45]_{2s}$ ,  $[90_2/\pm 45]_{2s}$  and  $[0/90/\pm 45]_{2s}$  laminate layups and found that room temperature wet (1.5% moisture content by weight) bearing strengths decreased by 11, 10 and 13%, respectively, compared with the room temperature-dry baseline condition. At 260°F and the same wet condition, the bearing strengths decreased by 38, 39 and 40%, respectively. No other investigators have reported this much of strength reduction.

### **1.5.6 Human and Machining Parameters**

Technicians and engineers can make mistakes or imperfections during specimens preparation and bolt installation. Similarly, machining tools do not always produce good quality and dimensional accuracy needed, especially if alignment and maintenance are not maintained properly on a timely and regular basis. Extremely limited studies have been performed on the effects of these human and machining parameters on bolted joints. Some of these issues were addressed by Garbo and Ogonowski [1-26] in 1981. For the sake of convenience, the following symbols are denoted:

RTD = Room temperature dry condition;

ETW = Elevated temperature (250°F) wet (0.86% moisture content) condition.

***Out-of-Round Holes.*** The testing results in Ref. [1-26] show that a bolted hole with a 0.004 in. straight portion in the middle (see Figure 1-21) causes 1.3% decrease and 4.3% increase in bearing strength of AS1/3501-6 30/60/10 and 50/40/10 respectively, at RTD.

**Delaminations.** Drilling a hole in composite laminates without a backing material and/or at too fast a feeding speed can cause delamination and fiber breakout on the exit side of the hole. Garbo and Ogonowski [1-26] reported reduction in bearing strengths of 2.0 and 7.3% at RTD with moderate and severe delaminations, respectively, in 50/40/10 laminates. At ETW, the loss in bearing strength with these type delaminations was 3.7 and 8.7%, respectively.

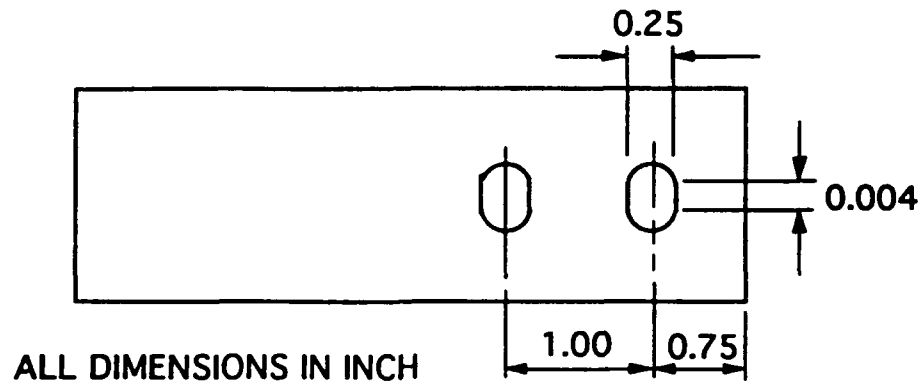
**Porosity.** Porosity can easily be formed during the processing of composite laminates. As shown in reference [1-26], moderate and severe porosity can cause reduction in bearing strengths for 50/40/10 laminates by 8 and 12%, respectively, at room temperature and after exposure to freeze-thaw cycles. The reductions increased to 13 and 30% when the laminates were tested at ETW condition.

**Improper Fastener Seating.** This happens when the countersink tool wobbles and produces a countersunk angle that does not match the angle on the head of the fastener. The result is that the bolt head sits below or protrudes above the laminate surface. Extreme cases were considered with 80 and 100% of the countersink head hanging free (only 20% of the laminate thickness or a circumferential line (knife edge) was in contact with the bolt). The bearing strengths were decreased by 20 and 53%, respectively, for 50/40/10 laminates at RTD condition.

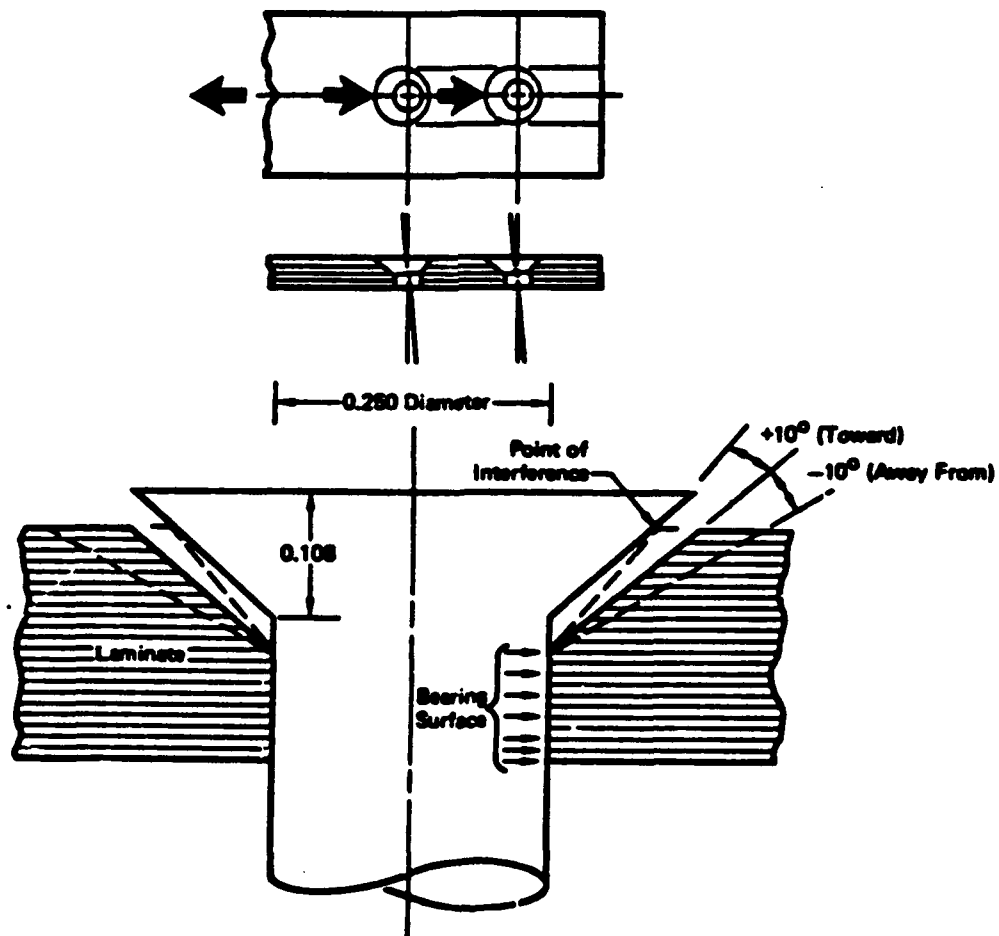
**Tilted Countersink.** This problem is created if the hole drilling direction is not parallel to the thickness direction of the laminate, as shown in Figure 1-21. Both toward and away from bearing conditions were studied. Here, "toward" and "away" mean that either smaller and or countersink angles were formed in the laminate. The reduction in bearing strengths of the 50/40/10 laminates were 18 and 14% at RTD and ETW conditions, respectively, in the "toward" case. For the "away" case, the changes in bearing strengths were +1% (increase) and -13% (decrease), respectively, at RTD and ETW conditions, respectively.

## **1.6 LOAD-DEFLECTION RESPONSE**

The load-deflection relationships have been measured by using applied load versus machine crosshead displacement or versus specimen deflection as recorded with extensometers. Results obtained by both of these techniques are discussed in the following sections.



(a) out-of-round hole



(b) tilted countersink

**Figure 1-21. Schematic diagrams of (a) out-of-round hole and (b) tilted countersink and specimen configuration.**

### 1.6.1 Load-Crosshead Displacement

Kretsis and Matthews [1-31] tested the applied load versus the crosshead displacement of some GI/69 (glass/epoxy) laminates with single-bolted joints. Their results showed that tension and shear failure modes are much more catastrophic than the bearing failure mode, Figure 1-22. These three failure modes were generated using three different specimen geometries. One must be very careful in the examination of these load-displacement relationships. Although the bearing curve has highest failure load among the three modes considered, the

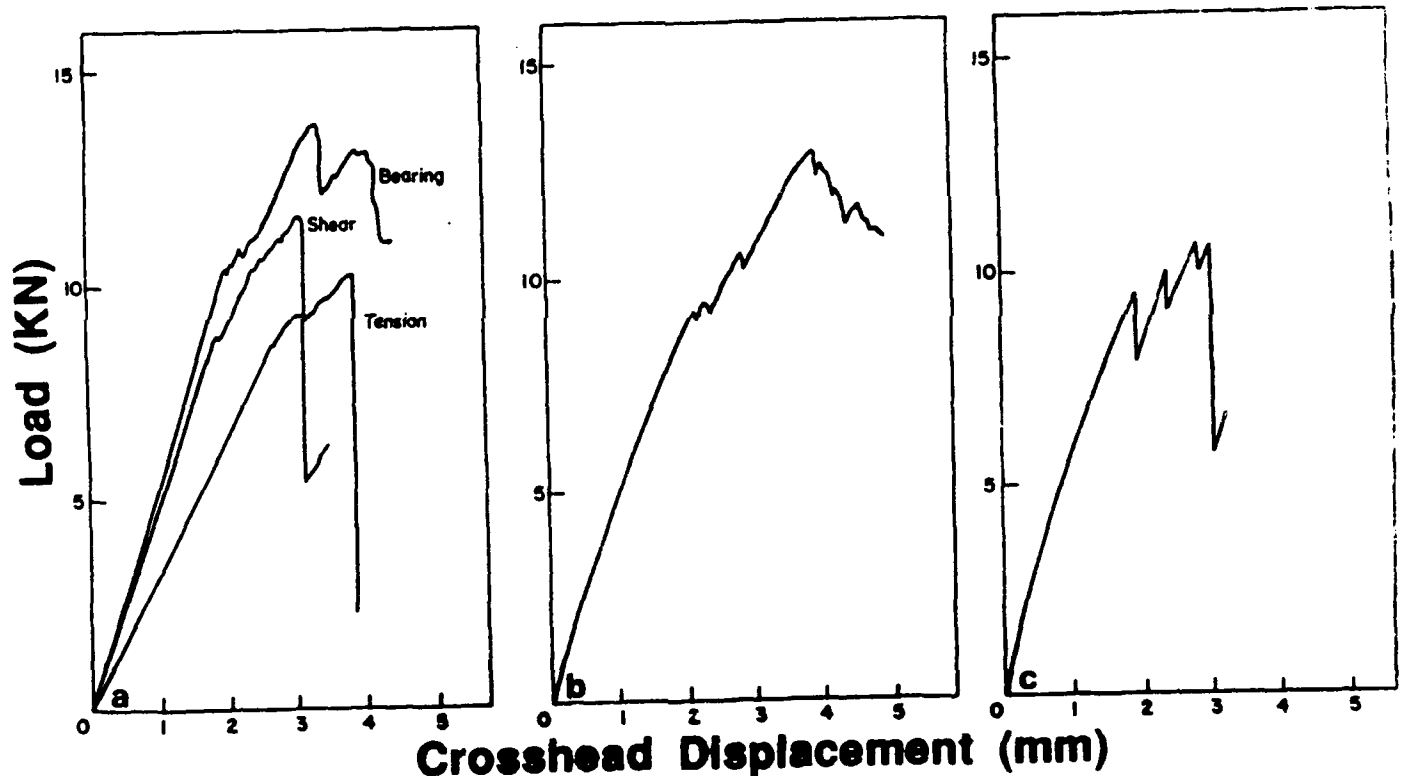


Figure 1-22. Load-displacement curves for GI/69 laminates with  $D=6.35$  mm (0.25"),  $t=3$  mm (0.12") and clamping pressure=12 MPa. (a)  $[0/\pm 45]_2s$ , bearing:  $W=40$  mm,  $e=30$  mm; tension:  $W=17$  mm,  $e=25$  mm; shear:  $W=40$  mm,  $e=16$  mm; (b)  $\pm 45$  symmetric, bearing:  $W=60$  mm; (c)  $0/90$  symmetric, bearing:  $W=45$  mm,  $e=40$  mm.

tension failure produce the highest gross fracture strength.

### 1.6.2 Load-Extensometer Measurements

Joint stiffness of a specimen with bolted joints is normally measured using extensometers. It is not a material property of the fastener or the laminate, rather, it is a structural property that depends on the fastener type and material, the laminate configuration and the joint type. Therefore, when the value of joint stiffness is reported, the joint configuration and the length of the extensometer used as well as its location must be specified. Most investigators did not measure this property. Only a limited number of references can be found in the literature. They are discussed in the following.

Ramkumar and Tossavainen [1-25] studied the joint stiffness of Gr/Ep (AS1/3501-6) laminates using 87.6 mm (3.45 in) long extensometers. It can be seen from their pictures that the locations of the extensometers were at the two ends of the specimens. The load-deflection curve for solid pin fasteners is generally composed of three portions. The first portion (initial offset) represents the region where friction between the laminate and the aluminum coupons (this is created due to lateral constraint applied through fasteners) is overcome. Thus, a higher fastener torque normally produces a larger initial offset region. The second portion is linear and the third portion is nonlinear and unsmooth. Significant damage is accumulated in this portion of the loading history. The joint stiffness is normally measured from the second region of this load-deflection curve. Some of the representative results under tensile loading are illustrated in Figures 1-23 through 1-27. Figures 1-23 and 1-24 show the results for Gr/Ep  $[(45/0/-45/0)_2/0/90]_s$  (50/40/10) laminates. Figures 1-25 and 1-26 are for  $[45/0/-45/0_3/90/0_3]_s$  (70/20/10) layups. Figure 1-27 illustrates test results for a  $[45/0/-45/0/45/90/-45/0/\pm 45]_s$  (30/60/10) laminate. The compression results are illustrated in Figures 1-28 and 1-29 for  $[(45/0/-45/0)_2/0/90]_s$  (50/40/10) and  $[45/0/-45/0_3/90/0_3]_s$  (70/20/10) laminates, respectively. The joint type (single or double lap), the fastener type (PH, CSK-T and CSK-S stand for protruded head, countersink with tension head and countersink with shear head, respectively) and the torque applied at the fastener are indicated at the upper left corner in all figures. The characteristics of these curves are similar regardless of the joint type and fastener type and material.

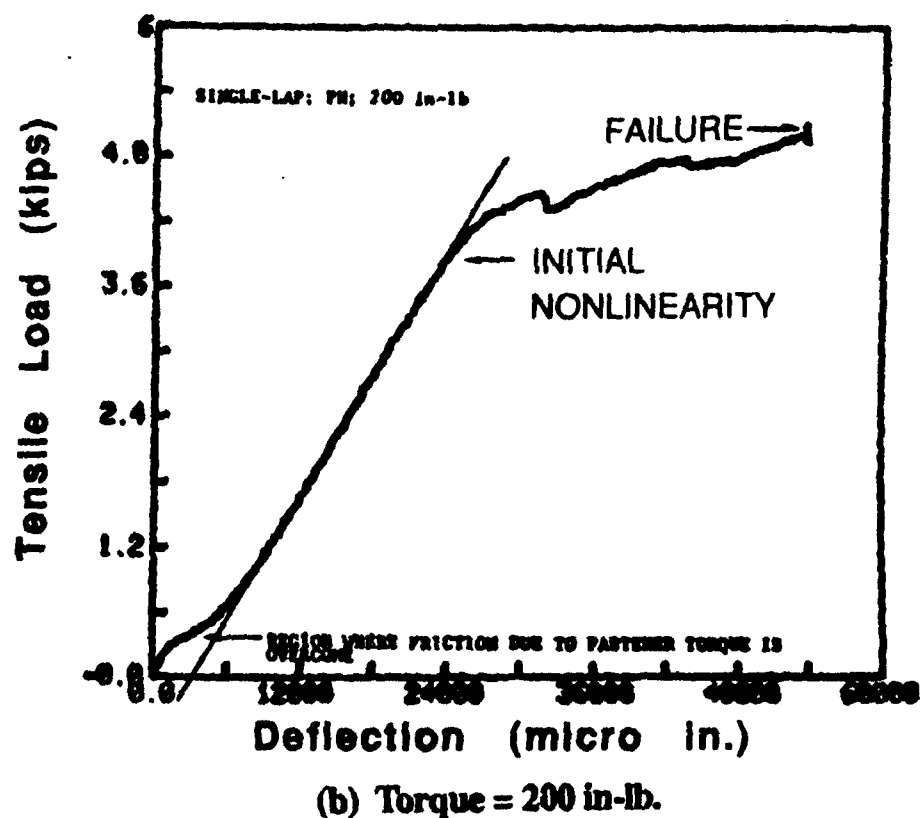
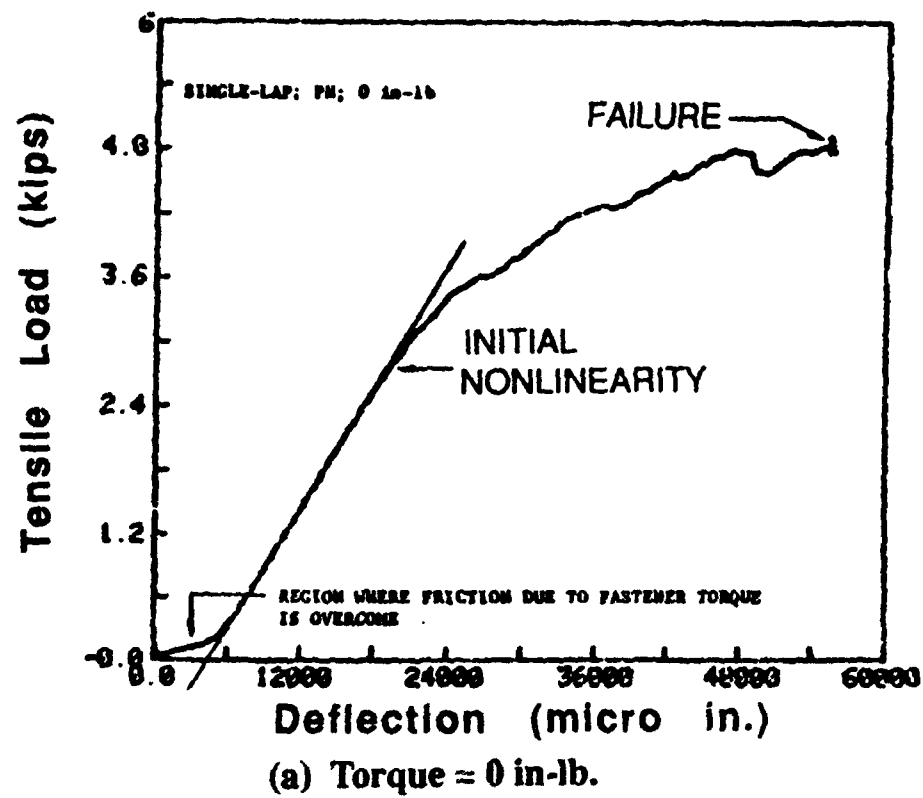
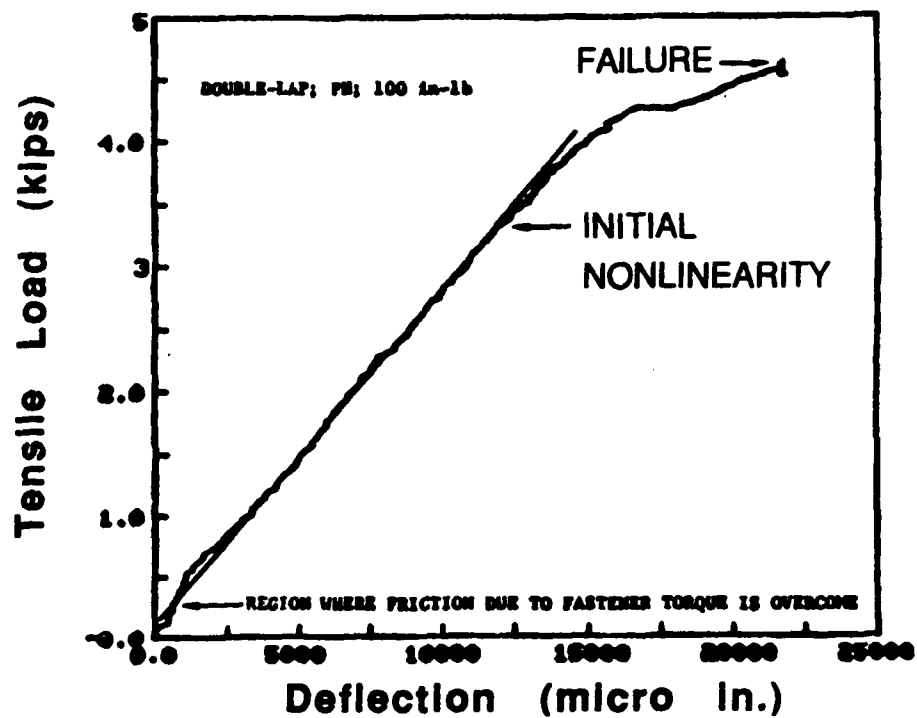
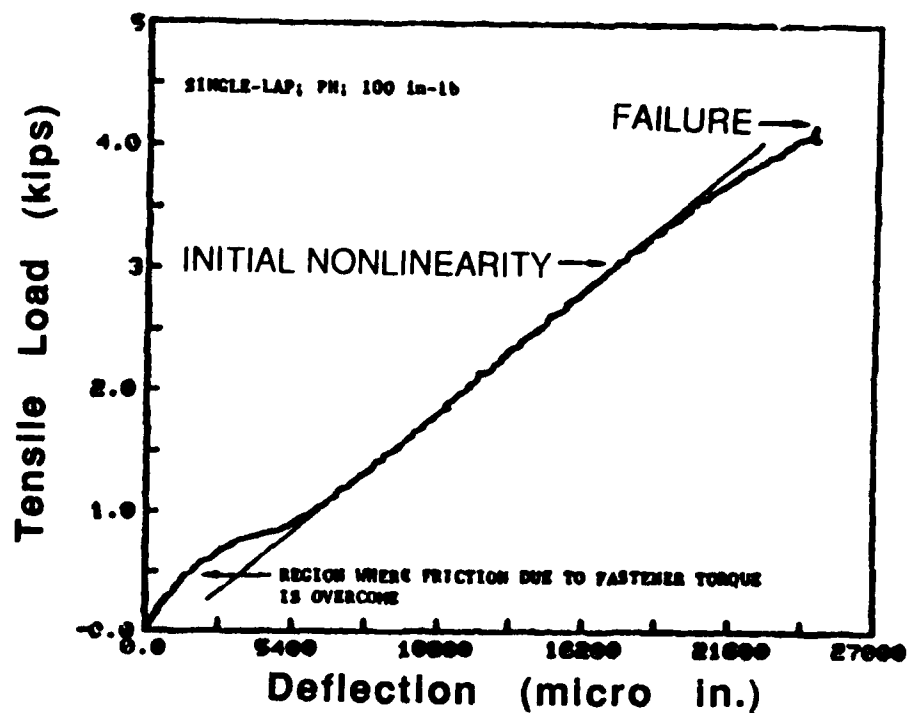


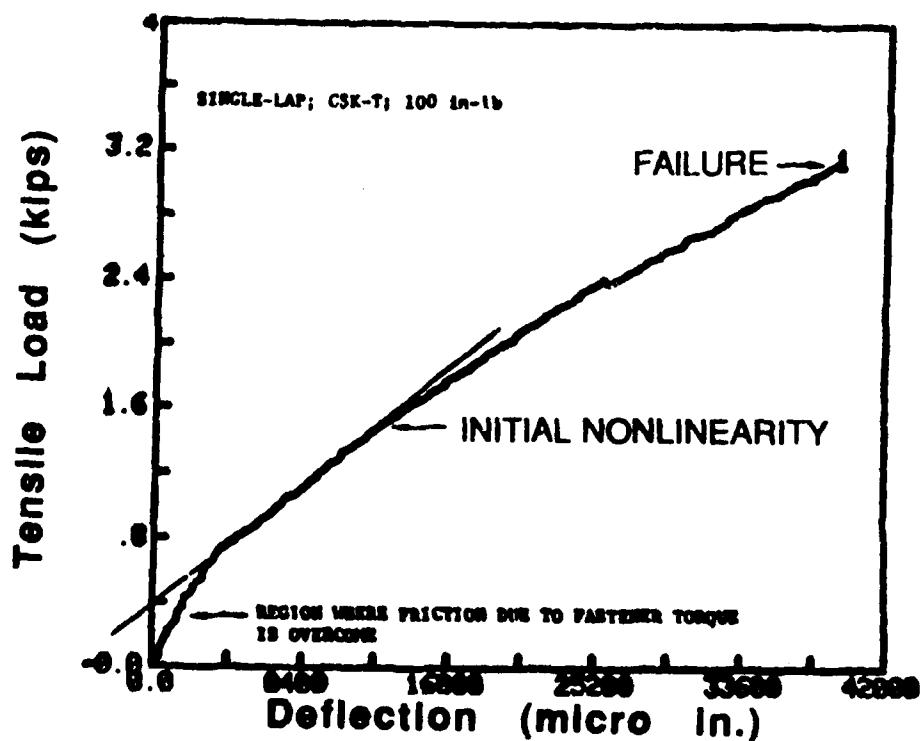
Figure 1-23. Load-deflection of Gr/Ep [(45/0/-45/0)<sub>2</sub>/0/90]<sub>s</sub> laminate with single lap-single joint and under tensile loading.



**Figure 1-24. Load-deflection of Gr/Ep  $[(45/0/-45/0)_2/0/90]_S$  laminate with double lap-single joint and under tensile loading.**

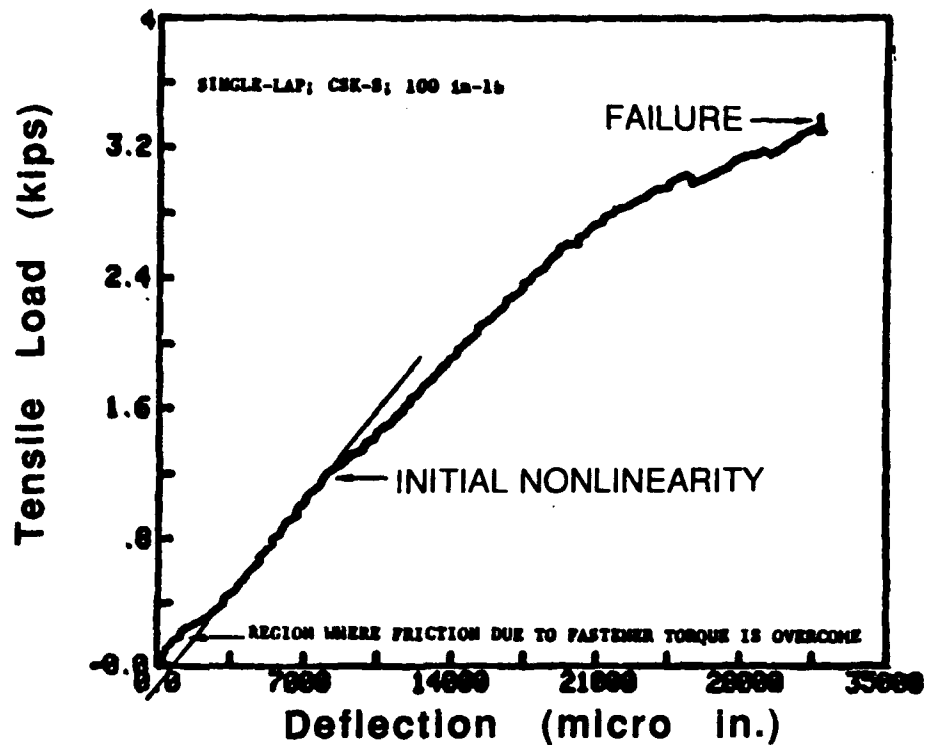


(a) Protruding head fastener.



(b) Countersunk tension head fastener.

Figure 1-25 Load-deflection of Gr/Ep [45/0/-45/0<sub>3</sub>/90/0<sub>3</sub>]<sub>s</sub> laminate with single lap-single joint and under RTD, tensile loading.



(c) Countersunk shear head fastener.

Figure 1-25 (cont.). Load-deflection of Gr/Ep [45/0/-45/0<sub>3</sub>/90/0<sub>3</sub>]<sub>s</sub> laminate with single lap-single joint and under RTD, tensile loading.

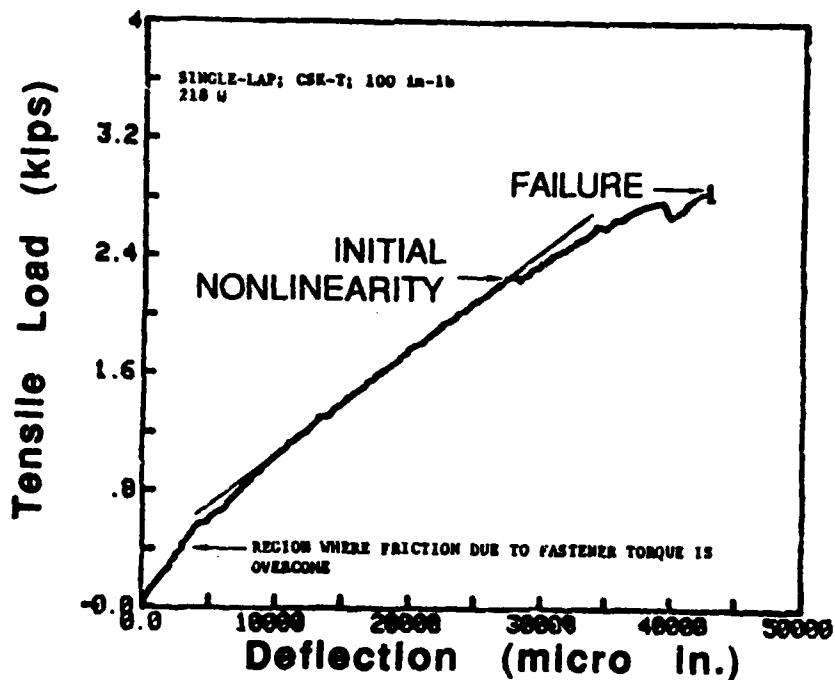
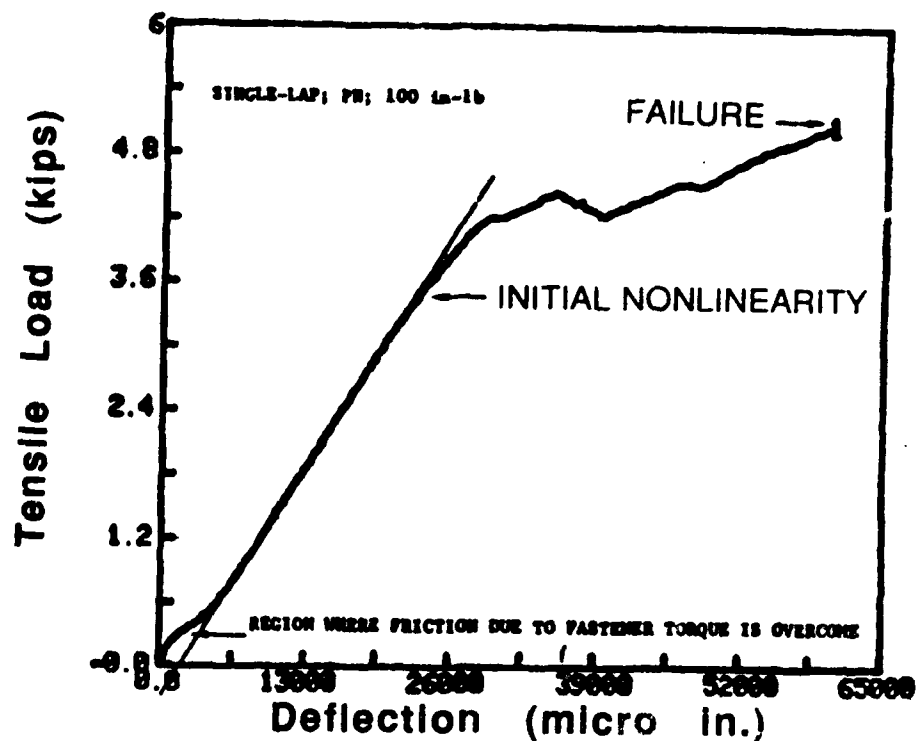
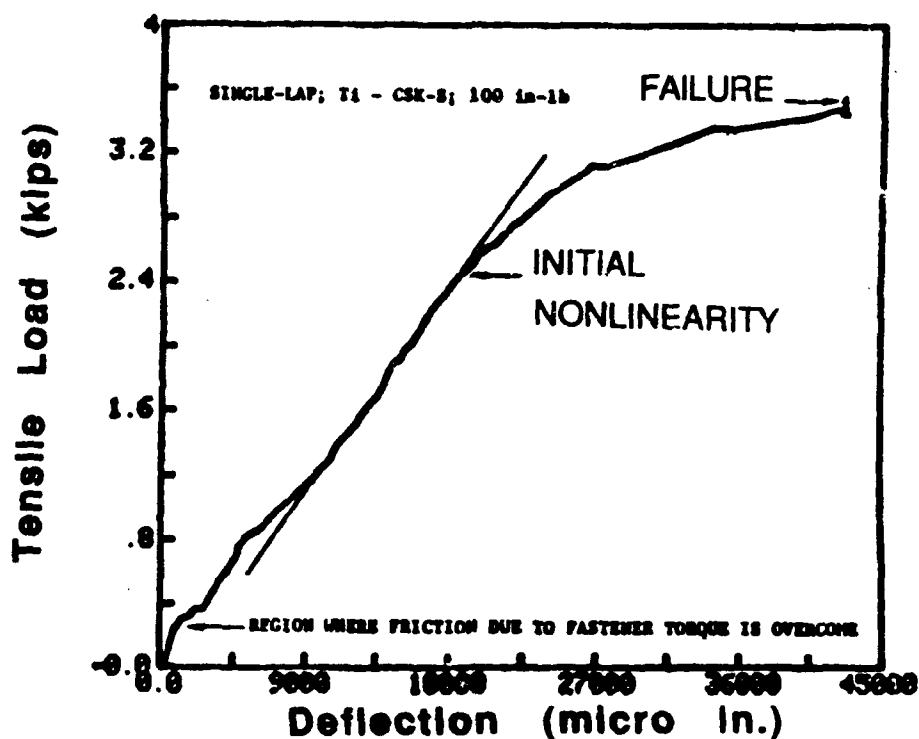


Figure 1-26. Load-deflection of Gr/Ep [45/0/-45/0<sub>3</sub>/90/0<sub>3</sub>]<sub>s</sub> laminate with single lap-single joint and under RTW, tensile loading.



(a) Steel Protruding head fastener.



(b) Ti countersunk shear head fastener.

Figure 1-27. Load-deflection of Gr/Ep [45/0/-45/0/45/90/-45/0/±45]<sub>s</sub> laminate with single lap-single joint and under RTD, tensile loading.

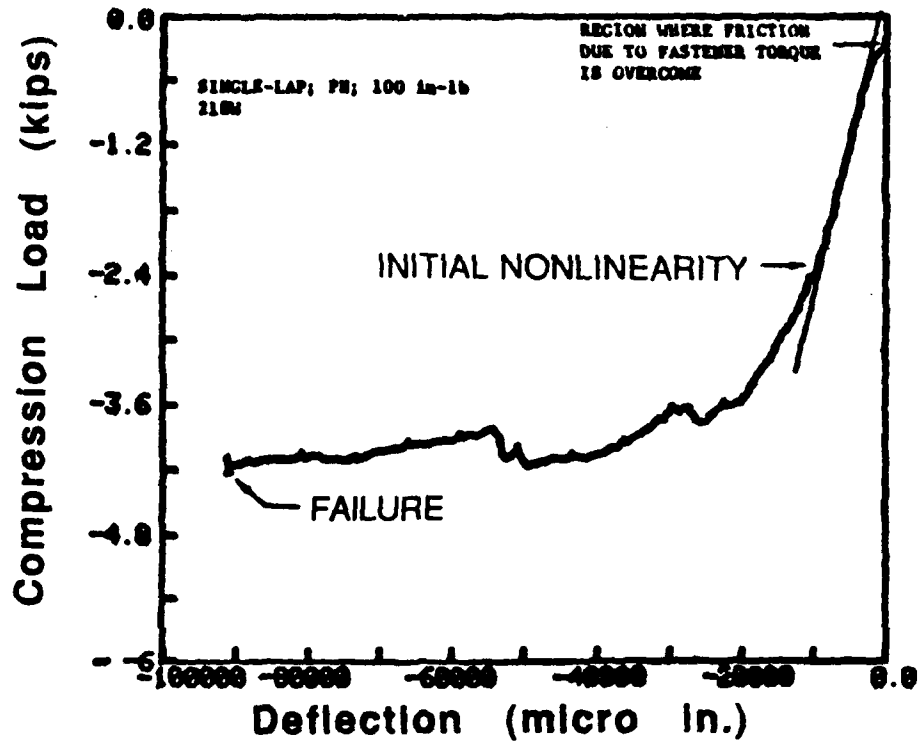


Figure 1-28. Load-deflection of Gr/Ep [(45/0/-45/0)<sub>2</sub>/0/90]<sub>s</sub> laminate with single lap-single joint and under RTD, compressive loading.

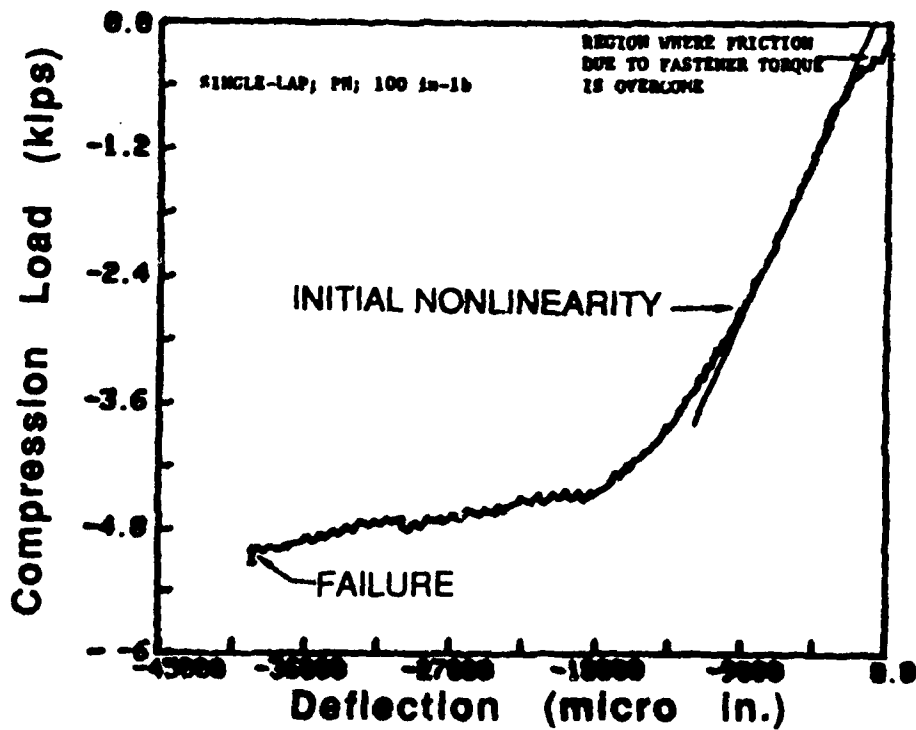


Figure 1-29. Load-deflection of Gr/Ep [45/0/-45/0<sub>3</sub>/90/0<sub>3</sub>]<sub>s</sub> laminate with single lap-single joint and under RTW, compressive loading.

## 1.7 DATABASE

Three computer programs have been written using the software called "Excel" (Version 2.2) in Macintosh computers. They are "Single J-Tension," "Bearing-Bypass" and "Multiple Joints" for laminated composites with single bolted-joints loaded in tension, bearing-bypass loading and multiple bolted-joints loaded in tension or compression, respectively. The contents of these programs are shown in the following:

A	B	C	D	E.....	...Z
1 Material	Percent of	Stacking	Plate	Plate....	Remarks
2 System	0/±45/90	Sequence	Width	Thicknes	
3 Fiber/Resin	plies		W(in.)	t (in.)..	
4 AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.876	0.120...	Gr/Ep
5 AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.875	0.118...	Ten. h.
6 AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.874	0.120...	Ti. Csk
7 AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.874	0.117...	St. Pr.
8 AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.875	0.120...	St. Csk
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
803	.	.	.	.	.
804 .....	.....	.....	.....	.....	.....

A hard copy of these tables are attached in Appendices A-1 to A-3. The first two Appendices contain 26 columns (from A to Z) while the last contains 30 columns (from A to Z to AD). If one clicks the column number at any column and goes to "sort" under the manual "Data," then he can rank the data in either ascending or descending order.

## 1.8 CONCLUSION

In the course of this work, the effects of many parameters on the bearing strength of bolted composite structures have been discussed. Among these parameters, lateral constraint provided by applying fastener torque stands out because it can improve the joint strength considerably. On the other hand, the harmful effects caused by human and machining parameters cannot be overlooked.

Limited test results show that these parameters can reduce the joining strength of composite structures by as much as 50 percent.

Comparing the bearing strength curves versus the  $W/D$  and  $e/D$  ratios, the former changes the slope more abruptly than the latter. When these ratios reach their critical values, the failure modes change from tension and shearout, respectively, to bearing. Their fracture strengths approach the same limit, namely, bearing strength.

Most investigators in this area focus on achieving full bearing strength. The reason is that this kind of failure mode is less catastrophic than the other two. However, one must keep in mind that achieving full bearing strength often does not produce optimum load-transfer efficiency. The calculation of gross strength for a laminate with bolted-joints is a good check for the efficiency.

The application of bolted-joints to composite structures has the advantages that it is a simple and cost effective method. This process has the disadvantage that it removes a considerable amounts of good material, which in turn introduces a significant stress concentration around the hole. The joining efficiency is considered medium to low. It is a great challenge to improve the efficiency of this joining method.

The testing of bolted joints with a single bolt, two bolts in a line, and three bolts in a line between composite to metal and composite to composite have been standardized in military handbooks. Details of the testing procedure and the specimen configuration can be found in Refs. [49] and [50].

## REFERENCES

- 1-1. Bohlmann, R. E., G. D. Renieri and M. Libeskind, "Bolted Field Repair of Graphite/Epoxy Wing Skin Laminates," *Joining of Composite Materials*, ASTM STP 749, K. T. Kedward, Ed., American Society for Testing and Materials, 1981, pp. 97-116.
- 1-2. Sandow, F., "A Computer Aided Aircraft Structural Composite Repair System," 32th SAMPE Int. Conf. and Exhibition, Anaheim CA, April 6-9, 1987, pp. 551-557.
- 1-3. Hinkle, T. and J. Van Es, "Battle Damage Repair of Composite Structures," Air Force Technical Report, AFWAL TR-87-3104, March 1988.
- 1-4. Buchanan, D. L. and S. P. Garbo, "Design of Highly Loaded Composite Joints and Attachment for Wing Structures," NADC-81194-60, August 1981.
- 1-5. Watts, D. J., et al., "Development of Composites Technology for Joints and Cutouts in Fuselage Structure of Large Transport Aircraft," Semi-Annual Technical Report Number 1, ACEE-34-PR-3419, October 1984.
- 1-6. Kong, S. J., "Conceptual Design of a High Load Transfer Mechanical Attachment for Tail Structures," NADC-81216-60, August 1981.
- 1-7. Averill, S. W. and H. R. Zamani, "Development of High Load Joints and Attachments for Composite Structure," NADC-81220-60, August 1983.
- 1-8. Ramkumar, R. L., E. S. Saether and D. Cheng, "Design Guide for Bolted Joints in Composite Structures," Air Force Technical Report, AFWAL-TR-86-3035, March 1986.
- 1-9. Ramkumar, R. L., E. S. Saether and E. Tossavainen, "Design, Fabrication, Testing and Analysis of Bolted Structural Elements," Air Force Technical Report, AFWAL-TR-86-3033, July 1986.
- 1-10. Black, J. B., B. R. Fox and K. A. Linton, "Development of Composites Technology for Joints and Cutouts in Fuselage Structure of Large Transport

Aircraft," Technical Report ACEE-34-PR-3507, Douglas Aircraft Company, April 1985.

1-11. Fehrie, A. C., G. J. Gilbert and E. C. Young, et al., "Development of an Understanding of the Fatigue Phenomena of Bonded and Bolted Joints in Advanced Filamentary Composite Materials, Volume II, Fabrication, Inspection and Testing," Technical Report AFFDL-TR-72-64, Vol II, June 1972.

1-12. Godwin, E. W. and F. L. Matthews, "A Review of the Strength of Joints in Fibre-Reinforced Plastics, Part 1. Mechanically Fastened Joints," Composites, July 1980, pp. 155-160.

1-13. Hart-Smith, L. J., "Joints," Engineering Materials Handbook, Vol I, Composites, ASM International, 1987, pp. 479-495.

1-14. Dastin, S. J., "Joining and Machining Techniques," Handbook of Composites, Ed., G. Lubin, Van Nostrand Reinhold Co., New York, 1969, pp. 602-632.

1-15. Clifton, F. and D. L. Mead, "The Strength of Sheets and Joints in Unwoven Glass Fibre Reinforced Plastic Laminates," Royal Aircraft Establishment, Technical Report 70213, November 1970.

1-16. Matthews, F. L., A. A. Roshan and L. N. Phillips, "The Bolt Bearing Strength of Glass/Carbon Hybrid Composites," Composites, July 1982, pp. 225-227.

1-17. Hart-Smith, L. J., "Bolted Joints in Graphite-Epoxy Composites," NASA-CR-144899, June 1976.

1-18. Matthews, F. L., "Bolted Joints," Composites Design, 4th Edition, Chapter 18, S. W. Tsai, Ed., Think Composites, 1988.

1-19. Cole, R. T., E. J. Bateh and J. Potter, "Fasteners for Composite Structures," Composites, July 1982, pp. 233-240.

1-20. "SPI Handbook of Reinforced Plastics," Ed, S. S. Oleesky and J. G. Mohr, Reinhold, 1964.

- 1-21. Rufolo, A., "Design Manual for Joining of Glass Reinforced Plastics," US Naval Material Laboratory Report, Navship 250-634-1, August 1961.
- 1-22. Poulos, M., "Manufacturing Technology for Low-Cost Composite Fasteners," Air Force Technical Report, AFML-TR-79-4044, June 1979.
- 1-23. Prince, D. E., "Corrosion Behavior of Metal Fasteners in Graphite/Epoxy Composites," Air Force Technical Report, AFML-TR-77-30, Vols. I & II, March 1977.
- 1-24. Wall, E. L., "Fasteners for Use with Composite Materials," NASC Report No 78-01, Aerospace Industries Association of America, Inc, January 1978.
- 1-25. Ramkumar, R. L. and E. W. Tossavainen, "Bolted Joints in Composite Structures: Design, Analysis and Verification, Task I Test Results - Single Fastener Joints," Air force Technical Report, AFWAL-TR-84-3047, August 1984.
- 1-26. Garbo, S. P. and J. M. Ogonowski, "Effect of Variances and Manufacturing Tolerances on the Design Strength and Life of Mechanically Fastened Composite Joints, Vol. I. Methodology Development and Data Evaluation," Air Force Technical Report, AFWAL-TR-81-3041, April 1981.
- 1-27. Rowlands, R. E., M. U. Rahman, T. L. Wilkinson and Y. I. Chiang, "Single- and Multiple-Bolted Joints in Orthotropic Materials," Composites, July 1982, pp. 273-279.
- 1-28. Stockdale, J. H. and Matthews, F. L., "The Effect of Clamping Pressure on Bolt Bearing Loads in Glass Fibre Reinforced Plastics," Composites, Vol. 7, No 1, January 1976, p.34.
- 1-29. Collings, T. A., "The Strength of Bolted Joints in Multi-Directional CFRP Laminates," Composites, Vol. 8, No. 1, January 1977 p.43.
- 1-30. Collings, T. A., "On the Bearing Strengths of CFRP Laminates," Composites, July 1982, pp. 241-52.
- 1-31. Kretsis, G. and F. L. Matthews, "The Strength of Bolted Joints in Glass Fibre/Epoxy Laminates," Composites, Vol. 16, No 2, April 1985, pp. 92-102.

- 1-32. Crews, J. H. Jr., "Bolt-Bearing Fatigue of a Graphite/Epoxy Laminate," *Joining of Composite Materials*, ASTM STP 749, K. T. Kedward, Ed., American Society for Testing and Materials, 1981, pp. 131-144.
- 1-33. Quinn, W. J. and F. L. Matthews, "The Effect of Stacking Sequence on the Pin-Bearing Strength in Glass Fibre Reinforced Plastic," *J. Composite Materials*, Vol. 11, April 1977, pp. 139-145.
- 1-34. Smith, P. A. and K. J. Pascoe, "The Effect of Stacking Sequence on the Bearing Strengths of Quasi-Isotropic Composite Laminates," *Composite Structures*, Vol. 6, 1986, pp. 1-20.
- 1-35. Pyner, G. R. and F. L. Matthews, "Comparison of Single and Multi-Hole Bolted Joints in Glass Fibre Reinforced Plastic," *J. Composite Materials*, Vol. 13, July 1979, pp. 232-239.
- 1-36. Ramkumar, R. L., E. S. Saether and K. Appa, "Strength Analysis of Laminated and Metallic Plates Bolted Together by Many Fasteners," Air Force Technical Report, AFWAL-TR-86-3034, 1986.
- 1-37. Ramkumar, R. L. and E. Tossavainen, "Bolted Joints in Composite Structures: Design, Analysis and Verification, Task II Test Results — Multifastener Joints," Air Force Technical Report, AFWAL-TR-85-3065, 1985.
- 1-38. Garbo, S. P., J. M. Ogonowski and H. E. Reiling, Jr., "Effect of Variances and Manufacturing Tolerances on the Design Strength and Life of Mechanically Fastened Composite Joints, Vol. 2 - Test Data, Equipment and Procedures," Air Force Technical Report, AFWAL-TR-81-3041, April 1981.
- 1-39. Godwin, E. W., F. L. Matthews and P. F. Kilty, "Strength of Multi-Bolt Joints in GRP," *Composites*, July 1982, pp. 268-272.
- 1-40. Chang, F. K., R. A. Scott and G. S. Springer, "Strength of Bolted Joints in Laminated Composites," Air Force Technical Report, AFWAL-TR-84-4029.
- 1-41. Ramkumar, R. L., "Bolted Joint Design, Test Methods and Design Analysis for Fibrous Composites," Ed. C. C. Chamis, ASTM STP 734, 1981, pp. 376-95.

- 1-42. Garbo, S. P., "Effects of Bearing/Bypass Load Interaction on Laminate Strength," AFWAL-TR-82-3114, September 1981.
- 1-43. Concannon, G., "Design Verification Testing of the X-29 Graphite/Epoxy Wing Covers," Proceedings of the Fall Meeting, Society of Experimental Stress Analysis, Salt Lake City, Utah, 1983, pp. 96-102.
- 1-44. Crews J. H, Jr and R. A. Naik, "Combined Bearing and Bypass Loading on a Graphite/Epoxy Laminate," Composite Structures, Vol. 6, 1986, pp. 21-40.
- 1-45. Naik, R. A. and J. H. Crews, Jr. "Ply-Level Failure Analysis of a Graphite/Epoxy Laminate Under Bearing-Bypass Loading," NASA Technical Memorandum 100578, March 1988.
- 1-46. Crews, Jr. J. H., "Bolt-Bearing Fatigue of a Graphite/Epoxy Laminate." ASTM STP 749, K. T. Kedward, Ed., American Society for Testing and Materials, 1981, pp. 131-144.
- 1-47. Wilkins, D. J., "Environmental Sensitivity Tests of Graphite/Epoxy Bolt Bearing Properties," Composite Materials: Testing and Design (Fourth Conference), ASTM STP 617, American Society for Testing and Materials, 1977, pp. 497-513.
- 1-48. Kim, R. Y. and J. M. Whitney, "Effect of Temperature and Moisture on Pin Bearing Strength of Composite Laminates," J. Composite Materials, Vol. 10, 1976, pp. 149-155.
- 1-49. Military Handbook, Structural Element Characterization, MIL-HDBK-17-1C, Volume I, Chapter 7, 1988.
- 1-50. MIL-STD-1312-X, Fastener Test Method X, Mechanically Attached Composite Shear Joint.

## **Chapter 2**

### **Adhesives and Bonded Joints**

#### **2.1 INTRODUCTION**

The study of structural adhesives and bonded joints of laminated composites and metals consisted of a literature search in the following publications: Journal of Adhesion, ASTM STP, International Journal of Adhesion and Adhesives, Journal of Composite Materials, Composites Science and Technology, Proceedings of SAMPE International Conference and Exhibition, Composites, books, NASA/DoD Technical Reports, technical reports from the commercial aircraft sectors, and technical reports from national laboratories, universities and centers. A listing of all documents researched on structural adhesives and bonded joints is included at the end of this chapter.

Adhesive joints in structures can provide higher load transferring efficiency than mechanical joints. With adhesive joints, material is not removed (in the form of drilled holes) from structures or structural components as in the case for mechanical joints. Generally, mechanical joints result in higher effective stress concentrations than do bonded joints. For these reasons, bonded joints have higher load carrying capability than mechanical joints provided the adhesives used have good mechanical properties and the surface preparation is good.

Bonded joints have been used in many areas of aircraft and aerospace structures [2-1 to 2-4]. The attaching mechanism that is used for bonded joints is adhesive. Most structural adhesives are cured at elevated temperature although many will cure at room temperature given sufficient time. Adhesives have been used exclusively in some structural components such as sandwich beams or sandwich plates. They are also one of the key components used for repair of aircraft structures [2-5 to 2-7]. Although the role of adhesives is very important in aircraft structures, the characterization methods for their

mechanical properties are not as well developed as they are for composite laminates. The available testing methods will be discussed briefly in the following sections.

In 1982, Matthews et al. [2-8] wrote a review paper in the area of adhesive bonded joints in fiber-reinforced plastics. The authors addressed theoretical works related to the lap shear test. On the contrary, this study places more attention on experimental work concerning adhesive properties in bulk and bonded form. This chapter discusses the properties of adhesives in bulk form and adhesive properties in lap shear configuration.

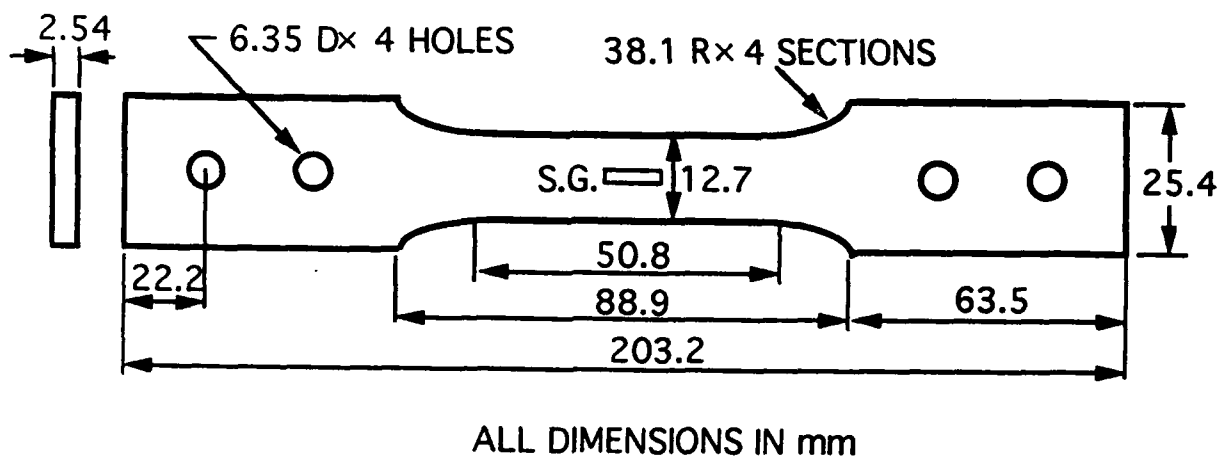
## **2.2 TESTING METHODS FOR ADHESIVE**

For a stress and strength analysis, mechanical properties, including moduli and Poisson's ratio are required. In addition to these, tensile, compressive and shear strength parameters are needed for failure analysis. In the application of fracture mechanics analysis, the values of critical energy release rate, denoted by  $G_{IC}$ ,  $G_{IIC}$  and  $G_{IIIC}$  are needed. The testing methods associated with all these parameters are discussed in the following sections.

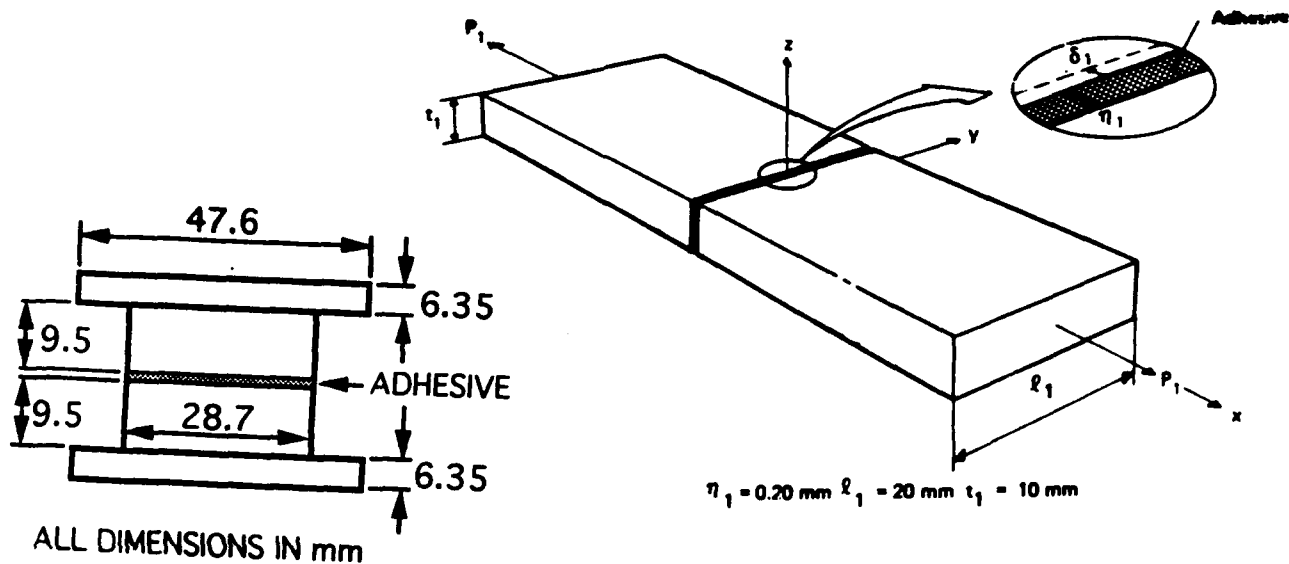
### **2.2.1 Normal and Mode I Properties**

Elastic properties and strengths can be evaluated using the following tests: (1) flat dog bone tension, Figure 2-1; (2) butt joint with circular, Figure 2-2 (ASTM D 897), rectangular, Figure 2-3, or square cross-sectional shape loaded in tension or compression; (3) sandwich flatwise tensile test, Figure 2-4 (ASTM C 297); (4) butt joint tension with cylindrical tubes, Figure 2-5; and (5) cross-lap tensile test, Figure 2-6 (ASTM D 1344).

The testing methods for determining Mode I critical energy release rate of adhesives include: (1) peel tests (which include T-peel ASTM D 1876, Figure 2-7; climbing drum peel, ASTM D 1781; and floating roller peel, ASTM D 3167); (2) thick blister (Figure 2-8); (3) butt joint tension; and (4) double cantilever beam (DCB). Specimens tested with butt joint in tension have 2% of mode II loading while the peel and the thick blister tests each contain 19 percent of mode II loading.

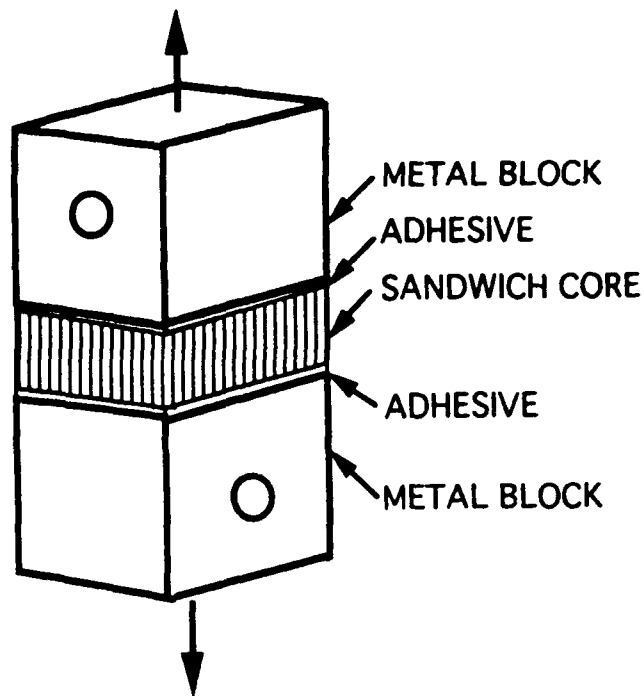


**Figure 2-1. Dog bone flat specimen for tensile test.**

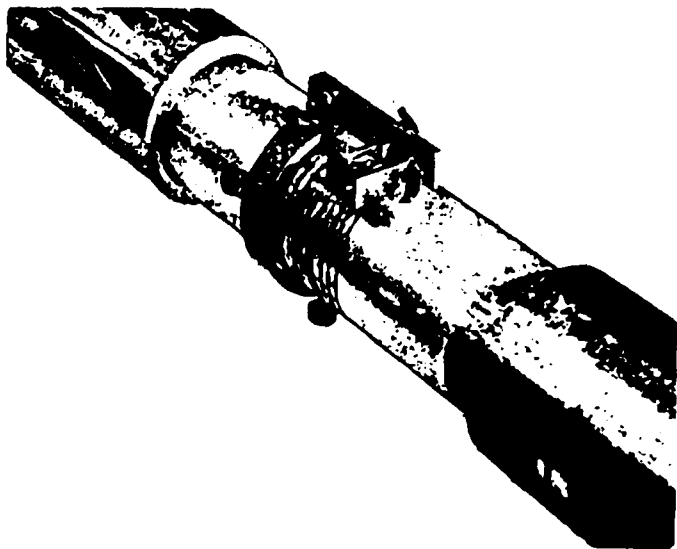


**Figure 2-2. Cylindrical butt-joint (ASTM D 897)**

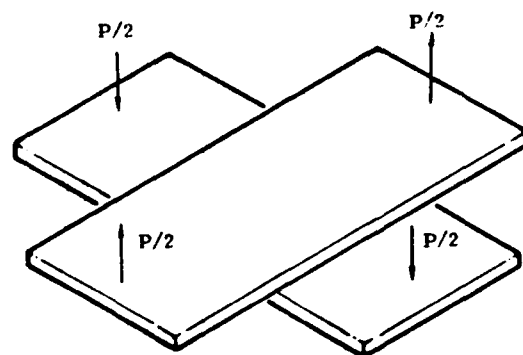
**Figure 2-3. Rectangular butt-joint.**



**Figure 2-4. Sandwich tensile test specimen.**



**Figure 2-5. Butt-joint with cylindrical tubes.**



**Figure 2-6. Cross-lap specimen.**

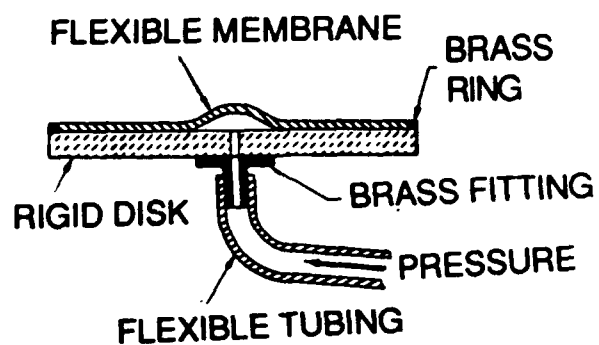
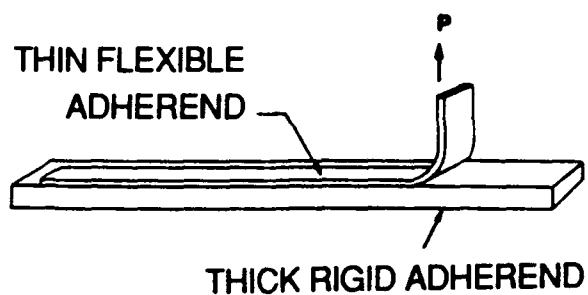
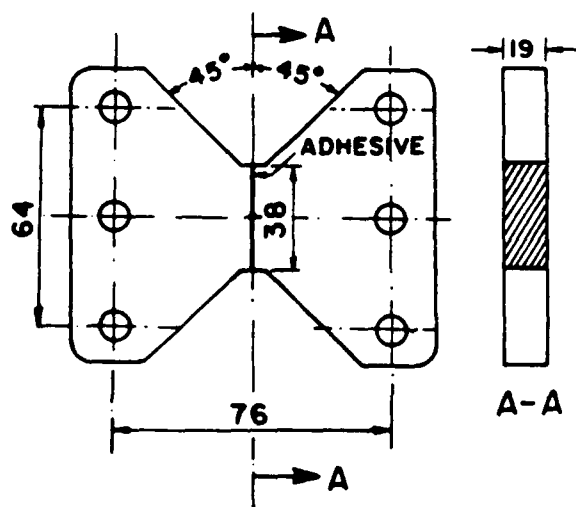


Figure 2-7. Peel test specimen.

Figure 2-8. Blister test specimen.



ALL DIMENSIONS IN mm



Figure 2-9. Stiff adherend specimen and fixture.

### **2.2.2 Shear and Mode II Properties**

Shear modulus and strength of adhesives can be evaluated using: (1) stiff adherend specimen, Figure 2-9; (2) butt joint with cylinders loaded in torsion (Figure 2-5); (3) bulk adhesive tube loaded in torsion, Figure 2-10; (4) thick adherend lap shear, Figure 2-11 (ASTM D 3983); (5) double lap shear (ASTM D 3528); (6) Napkin ring, Figure 2-12 (ASTM E 229-70 [2-9]); and (7) blocks loaded in compression, ASTM D 905-86 [2-10]. Testing methods of Mode II component include: (1) thin blister; (2) cylinder pull-out, Figure 2-13; and (3) cracked lap shear, Figure 2-14.

### **2.2.3 Mode III Properties**

Mode III critical strain energy release rate of adhesives can be measured using: (1) thick cracked-lap-shear specimen with out-of-plane loading, Figure 2.15; and (2) butt joint in torsion, Figure 2-2.

### **2.2.4 Mixed-Mode Loading**

Mixed-mode testing methods of adhesives include: (1) cracked lap-shear, Figure 2-14 (example can be found in Ref. [2-11]); (2) scarf joint [2-12]; (3) stiff adherend specimen with off-axis loading, Figure 2-16 (example can be found in Ref. [2-13]); (4) independently loaded mixed-mode (ILMM), Figure 2-17 [2-14]; and (5) flat coupon with adhesive-adherend bonded at 45° to the loading axis, Figure 2-18 [2-15]. Extremely limited studies have been done in this area. Stress analysis is critically needed to examine the uniformity of the stress distribution in the test specimens in order to obtain accurate material properties.

## **2.3 ADHESIVE PROPERTIES**

The results of adhesive property tests include normal stress-strain curve and strength, shear stress-strain curve and strength, the adhesive properties due to the effects of curing temperature, time and cool down rate, the creep properties, and thickness effects on the adhesive properties. More detailed discussion is given in the following sections.

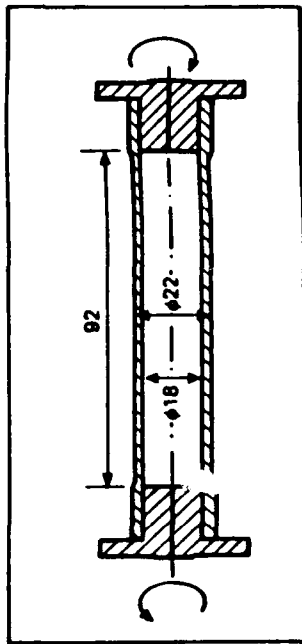


Figure 2-10. Bulk adhesive tube.

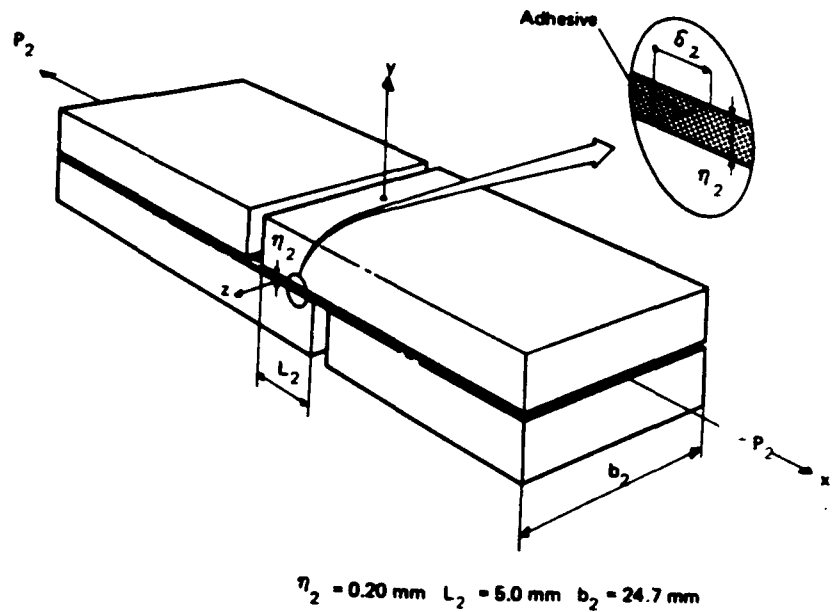


Figure 2-11. Thick adherend lap shear specimen.

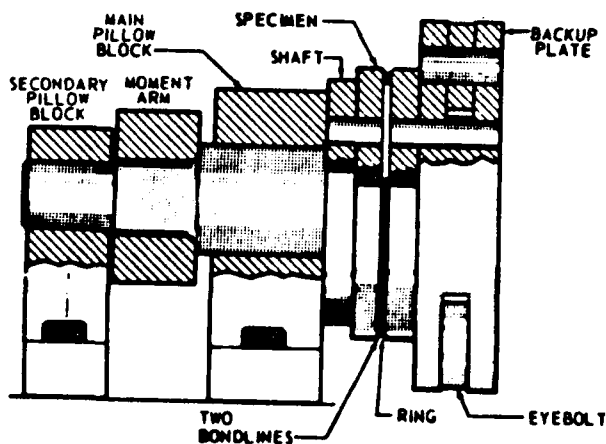


Figure 2-12. Napkin ring test (ASTM E 229)

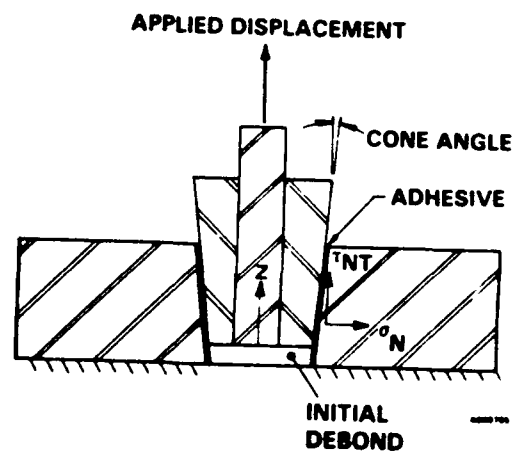
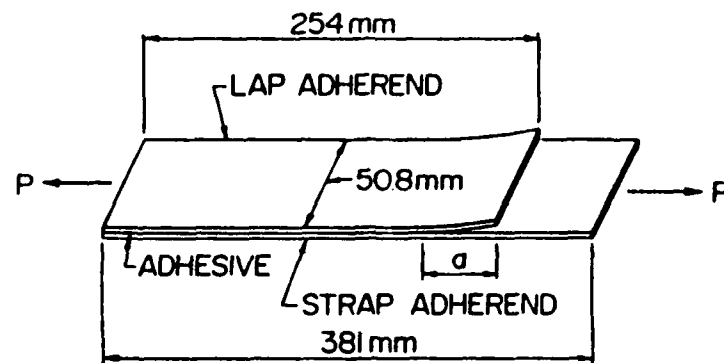
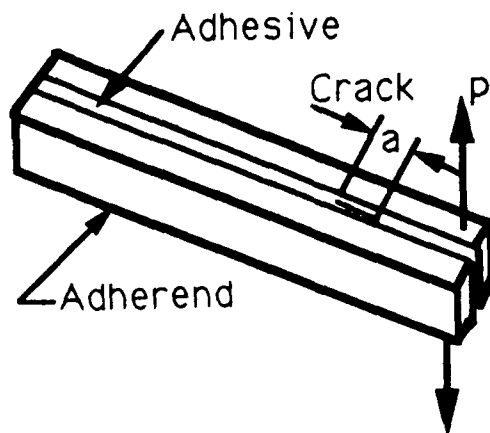


Figure 2-13. Cone test (cylinder pull-out).



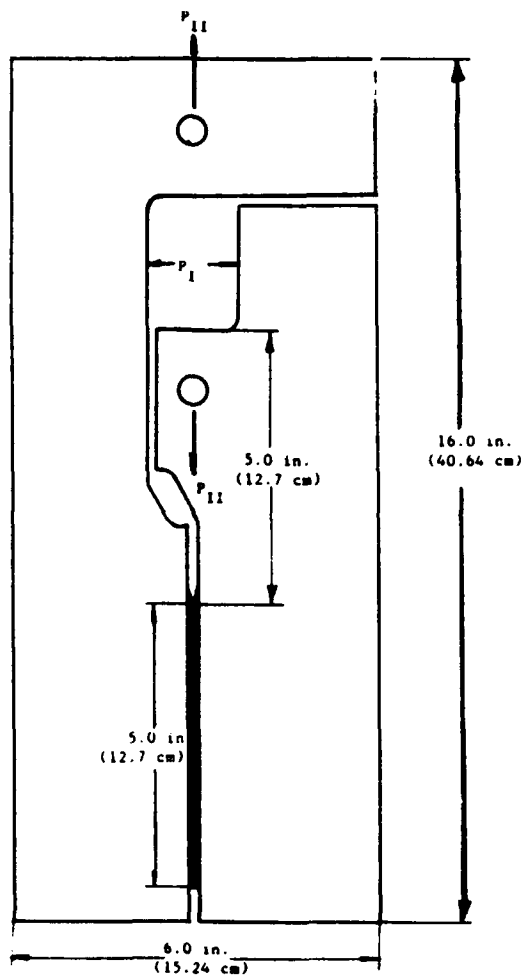
**Figure 2-14. Cracked lap-shear specimen.**



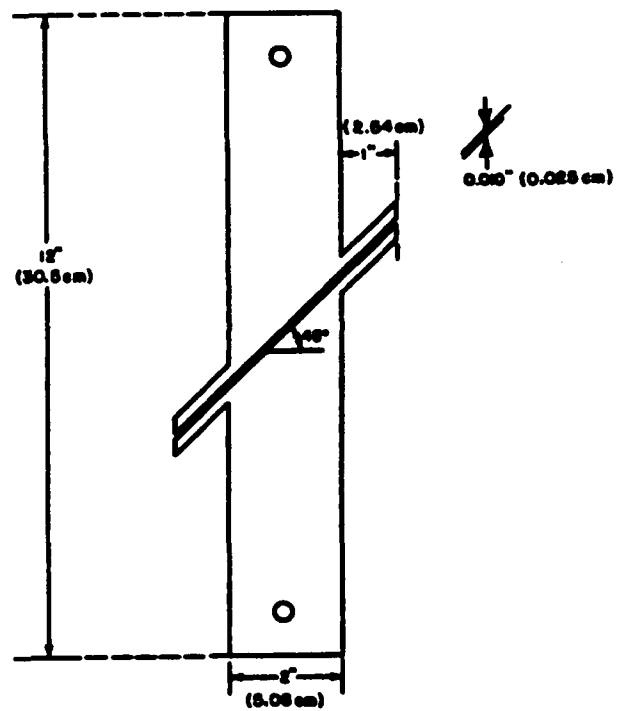
**Figure 2-15. Thick cracked-lap-shear specimen.**



**Figure 2-16. Stiff adherend specimen with off-axis loading.**



**Figure 2-17. ILMM specimen.**



**Figure 2-18. 45° mixed-mode flat specimen.**

### 2.3.1 Normal Properties

Adhesive materials are generally very nonlinear and temperature dependent. To describe the nonlinear stress-strain relationship, many engineers have employed the Ramberg-Osgood equation [2-16] which:

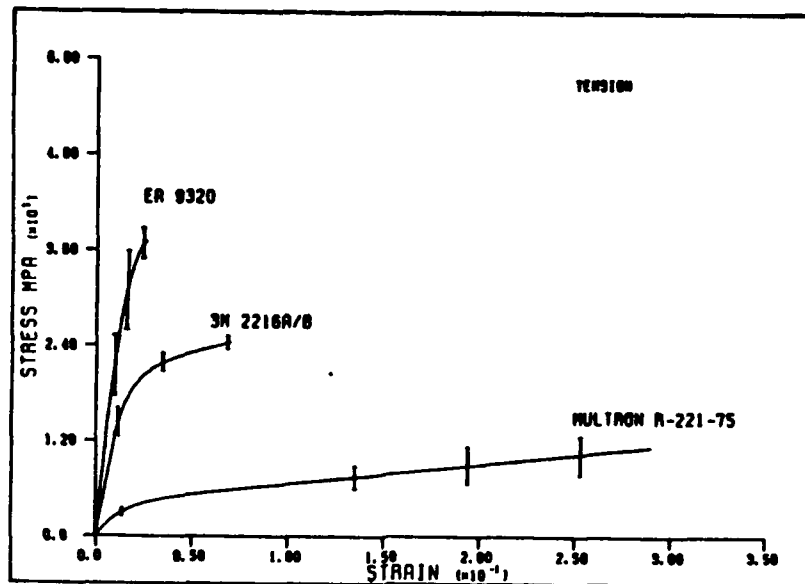
$$\epsilon = \frac{\sigma}{E} + K \sigma^n \quad (1)$$

where the first and second terms on the right-hand side of the equation represent elastic and plastic strains, respectively, and where  $E$ ,  $K$  and  $n$  are material parameters. Another equation which will be mentioned later is the modified Bingham model [2-17]:

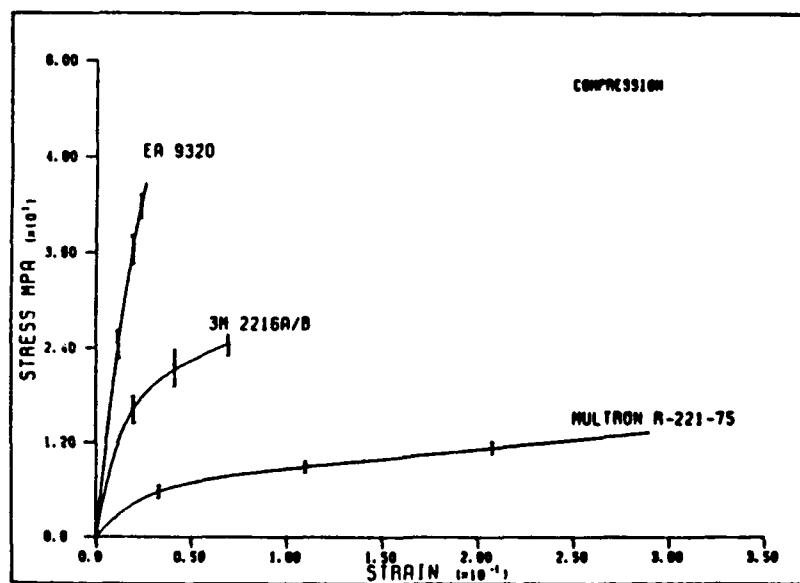
$$\begin{aligned} \sigma(\epsilon) &= E\epsilon, \text{ for } 0 < \sigma < \theta \\ \sigma(\epsilon) &= \theta + ER\tau \left[ 1 - e^{-(\epsilon - \epsilon_0)/R\tau} \right], \text{ for } 0 < \sigma < Y \end{aligned} \quad (2)$$

where  $\theta$  and  $Y$  denote the elastic limit and yield stress, respectively;  $R$  is the strain rate,  $\tau$  is the relaxation time, and  $\epsilon_0$  is the elastic limit strain.

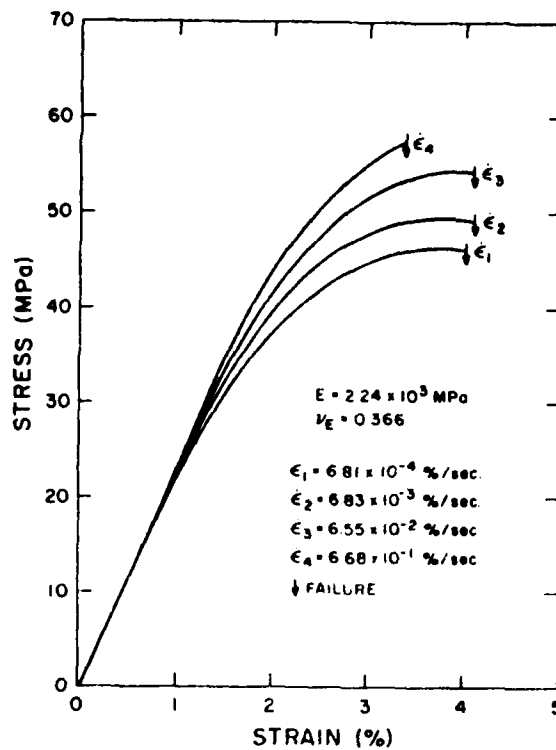
**Flat Dog Bone.** The normal components of the stress-strain curves for Hysol EA 9320, 3M Company 2216A/B and MULTRON R-221-75 adhesives have been studied under tensile and compressive loadings [2-18]. Flat dog bone specimens were used for the tensile tests whereas an adhesive block with a square cross-sectional shape was used for the compression tests. The shape of the stress-strain curves as well as the strength and fracture strain values for each adhesive are very similar for tensile, Figure 2-19, and compressive loadings, Figure 2-20. However, the failure modes obtained from these tests were not reported. Brinson et al. [2-19] also used dog bone specimens to characterize the normal stress-strain curves of adhesives. Figures 2-21 and 2-22 illustrate that the stress-strain behaviors of Metlbond 1113 and Metlbond 1113-2 are very nonlinear. They are quite sensitive to the strain rate applied. A higher strain rate results in a higher fracture strength for the adhesive. These authors also showed that the stress-strain curves of these adhesives can be characterized more accurately using a modified Bingham model, Eq. (2), rather than the Ramberg-Osgood model, Eq. (1). However, the Ramberg-Osgood equation is more widely used because of its simplicity.



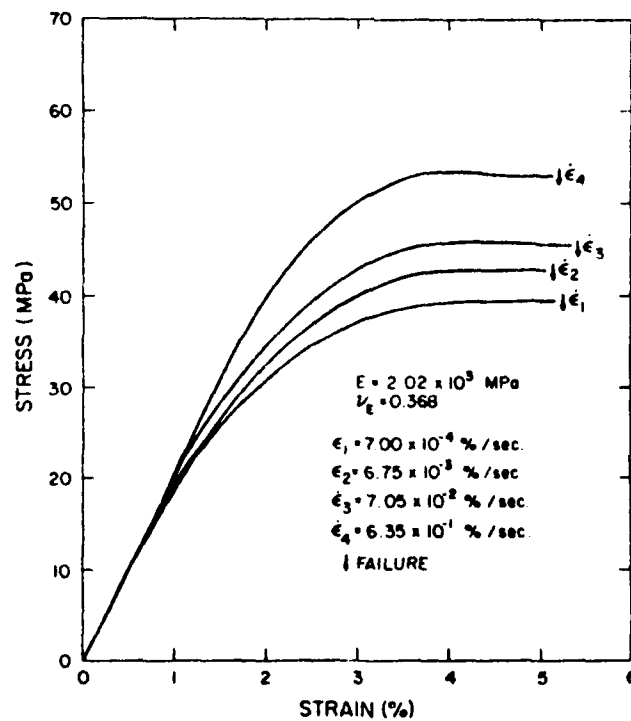
**Figure 2-19. Tensile stress-strain curves of adhesives.**



**Figure 2-20. Compressive stress-strain curves of adhesives.**



**Figure 2-21. Tensile stress-strain .vs. strain-rate relations of Metlbond 1113.**



**Figure 2-22. Tensile stress-strain .vs. strain-rate relations of Metlbond 1113-2.**

Other work that uses the dog bone flat specimens can be found in Ref. [2-20], which presents the tensile modulus and Poisson's ratio of Redux 322 epoxy film and Eccobond 45 LV two-part epoxy paste.

**Butt Joint-Thick Adherend.** The tensile modulus and Poisson's ratio of an adhesive can be measured by methods other than the flat dog bone. For instance, Jangblad et al. [2-21] evaluated these parameters using a combination method. With the assumption that the adherends are all rigid, two simple equations were obtained with Young's modulus and Poisson's ratio as unknowns. These unknowns can be solved using experimental results from butt joint (Figure 2-3) and thick adherend specimens (Figure 2-11). Jangblad et al. also performed tensile tests using flat coupons of bulk adhesive. The results obtained from the combination method (2504 MPa and 0.34) for FM-300K agree quite well with those measured using bulk adhesive (flat specimen, 2330 MPa and 0.39).

**Butt Joint.** The result of this test normally reported by experimentalists is simply the failure load divided by the cross-sectional area of the adhesive. The analyses performed by Messer [2-22] and Anderson, et al. [2-23] have shown that the axial stress component at the bonded edge tends to be unbounded. This result invalidates the application of maximum stress failure criteria and the simple idea of failure divided by the total cross-sectional area. With the development of a modified tensile test apparatus [2-23], the result of the tensile strength of polyurethane (Solithane 113) adhesive is 76% higher than that obtained using a standard button test method. Associated with this increase in strength was a reduction in the data coefficient of variation. The reported tensile strengths for this adhesive were 5.8 and 5.2 ksi for adhesive thickness equal to 0.065 and 0.006 inch, respectively. Additional data were reported in Refs. [2-24] and [2-25].

**$G_{IC}$ .** In 1988, Russell [2-26] used a double cantilever beam (DCB) method to measure the  $G_{IC}$  values for FM-300K, FM-300 and EA-9321 adhesives as a function of temperature. Figure 2-23 shows that  $G_{IC}$  values for the first two adhesives increase as temperature increases. On the other hand,  $G_{IC}$  for EA-9321 adhesive increases slightly to 50°C and then it decreases. Mall and Yun [2-27] reported that  $G_{IC}$  values for FM-400, FM-300 and EC-

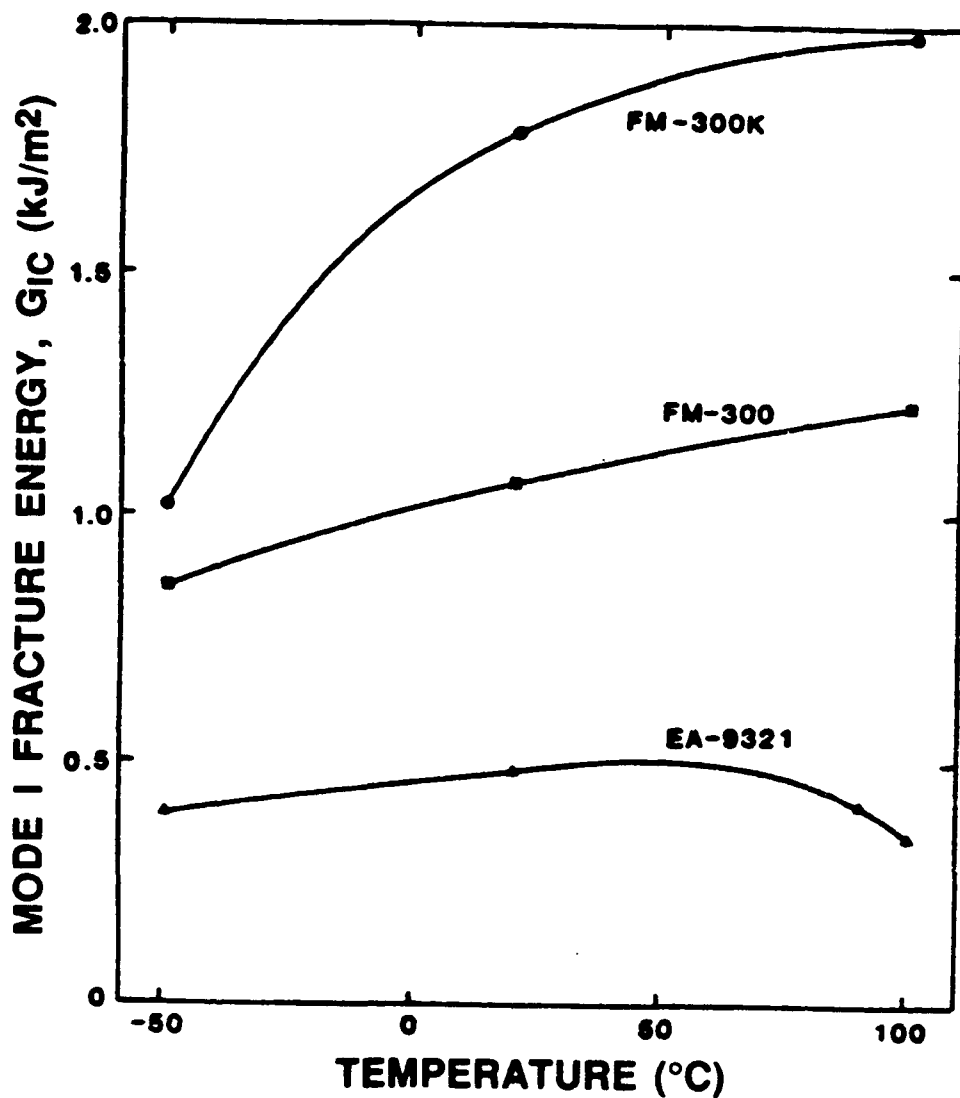


Figure 2-23. Effect of temperature on the  $G_{IC}$  of adhesives.

3445 were 603, 933 and 888 J/m<sup>2</sup>, respectively, where FM-300 was in close agreement with Russell's result. The  $G_{IC}$  values for other adhesives can be found in Refs. [2-28] and [2-29].

### 2.3.2 Shear Properties

Shear stress-strain behavior of adhesives can be determined using some of the shear testing methods mentioned above. Some of the representative results are discussed in the following section.

**Butt Joint with Cylindrical Tubes.** As early as 1963, Kuenzi and Stevens [2-30] characterized the shear stress-strain behavior of adhesives using a butt joint with cylindrical tubes, Figure 2-5. The materials studied include Redux K-6, AF-6, MN3C, Epon VIII, Metlbond 4021, FM 47, Epon 422J, Metlbond 408 and FM 1000 (Figure 2-24). A strength of materials approach was applied for data interpretation. No analysis has been performed to confirm the data measured.

**Stiff Adherend Specimen.** Weissberg and Arcan [2-13] performed a finite element analysis for a stiff adherend specimen loaded along the bondline direction. They compared this test specimen with a thick adherend specimen and showed that: (1) the peak value of the normal stress component (at the corner of the adhesive-adherend interface) in the adhesive is less than half of that in the thick adherend lap shear specimen; and (2) the normal stress decays much faster than that of the latter specimen. Shear strain was measured using a crack opening displacement gauge located across the adhesive. The result for EA 9321 adhesive is illustrated in Figure 2-25. The authors also performed a fracture mechanics analysis and confirmed with limited experimental data that the product of fracture shear stress and the normalized compliance change rate is a constant. That is, it is independent of the crack length.

**Thick Adherend Lap Shear.** In 1975, Renton and Vinson [2-31] characterized elastic properties,  $E$ ,  $G$  and  $\nu$ , of EA 951 film adhesive using the thick adherend lap shear test. An extensometer was placed on the outside surfaces of the fixture to measure the shear deformation. The deformation of the fixture was then subtracted from the measured deformation to obtain the adhesive deformation. The calculation was conducted using a strength of

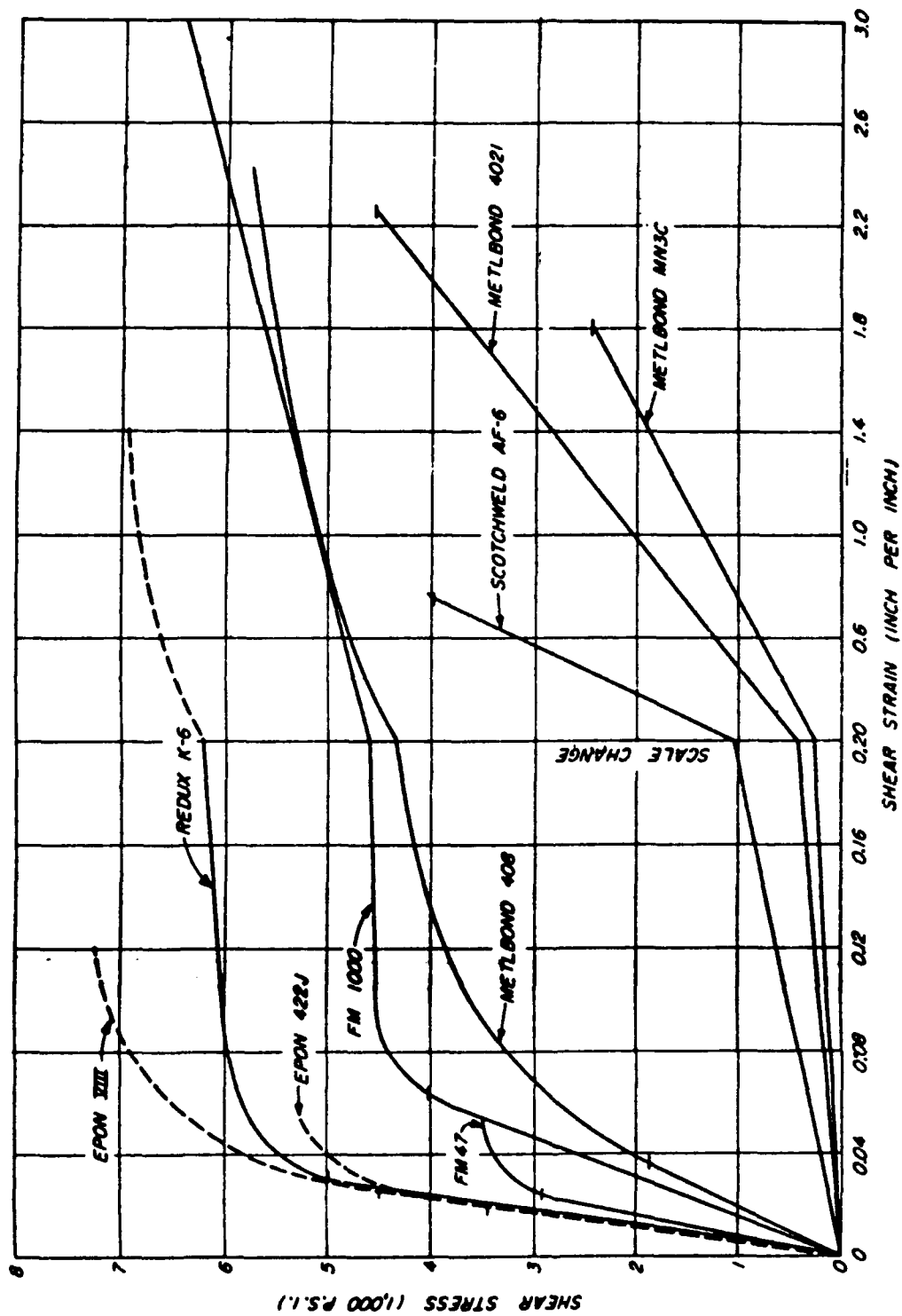


Figure 2-24. Shear stress-strain curves of adhesives measured by butt-joint with cylindrical tubes.

materials approach. The result shows that the tensile modulus is linearly dependent on the adhesive thickness. This result leads to uncertainty with respect to the applicability and accuracy of the thick adherend lap shear test.

Recently (1988), Post et al. [2-32] utilized a Moire Interferometry method to study the strain distribution of FM-73M adhesive in a thick adherend lap shear specimen, Figure 2-26. Aluminum, 2024-T3, was used for the adherend. The shear stress-strain curve was obtained nearly to the ultimate fracture of the specimen. They showed that the shear strain is mostly uniform in the adhesive except at the two ends. The transverse strain component was one to two orders of magnitude smaller than the shear strain. Therefore, shear stress-strain behavior should be accurate if measurements were made in the central portion of the adhesive. Deformations should be measured at points within the adhesive in order to achieve high accuracy.

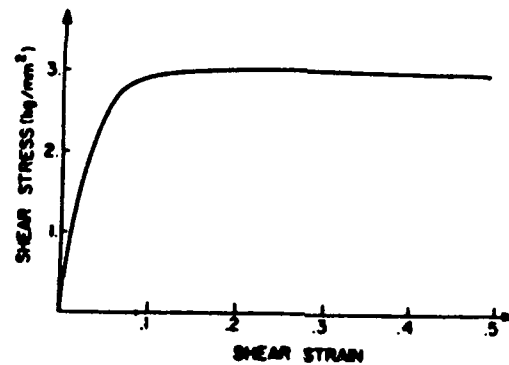
The shear stress-strain relations for Cybond 1115 and BR-100 (two-part epoxy paste adhesives) were characterized by American Cyanamid and presented in Ref. [2-33] using the thick adherend lap shear specimen. A KGR-1 extensometer was used to measure the deformation. The result is shown in Figure 2-27.

***Napkin Ring Shear Test.*** The shear stress-strain behavior of the FM-73 adhesive can be found in Ref. [2-34] and is shown in Figure 2-28. Comparing the results in Figures 2-26 and 2-28, it is interesting to note that shear strength and fracture strain evaluated by the napkin shear test are almost twice as high as those determined by a thick adherend lap shear test. On the contrary, the initial modulus (60 ksi) is only half that obtained from the adherend lap shear test.

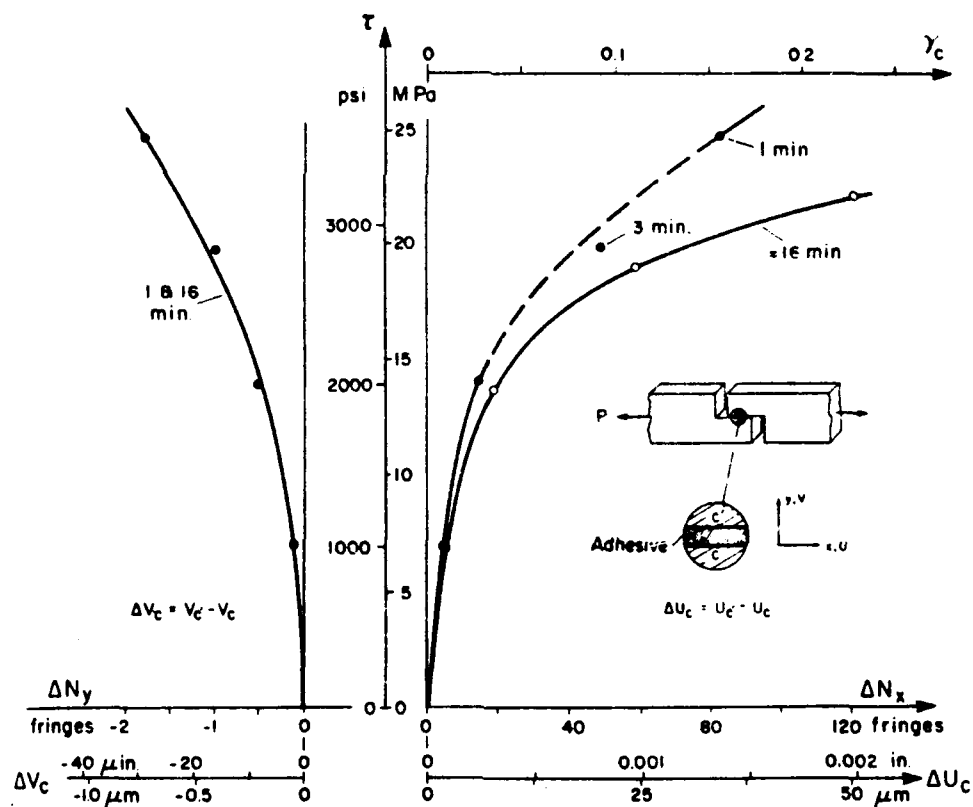
***Torsion Pendulum Test.*** Jeandrau [2-20] showed that the shear moduli for the Redux 322 epoxy film and Eccobond 45 LV epoxy paste, evaluated using a bulk adhesive tube, Figure 2-10 (NFT 51104) agreed very well with the thick adherend lap shear tests. The measurements using these two test methods both agree well with the value calculated from the following equation:

$$G = \frac{E}{2(1 + \nu)} \quad (3)$$

where G, E and  $\nu$  denote shear modulus, tensile modulus and Poisson's ratio,



**Figure 2-25. Shear stress-strain curve of EA 9321 adhesive measured by stiff adherend specimen.**



**Figure 2-26. Shear stress-strain curve of FM-73M adhesive evaluated using thick adherend specimen with Moire Interferometry.**

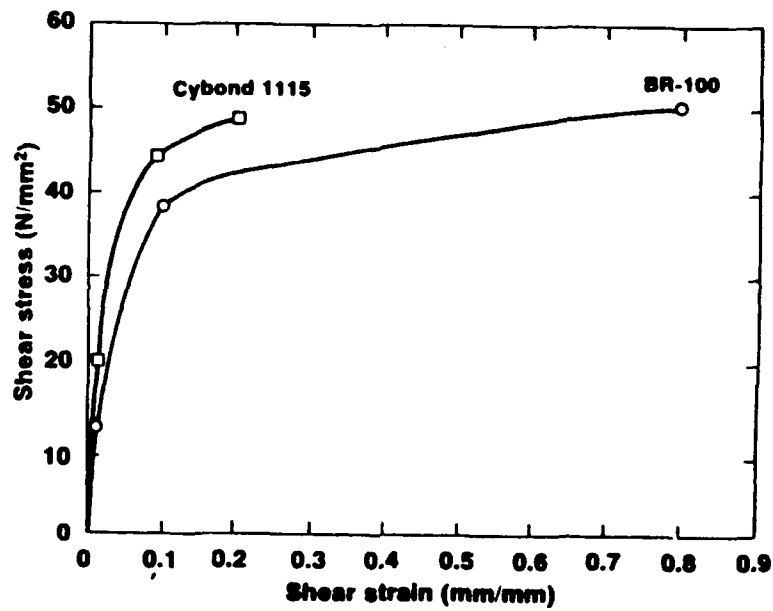


Figure 2-27. Shear stress-strain curves of adhesives measured using thick adherend specimen.

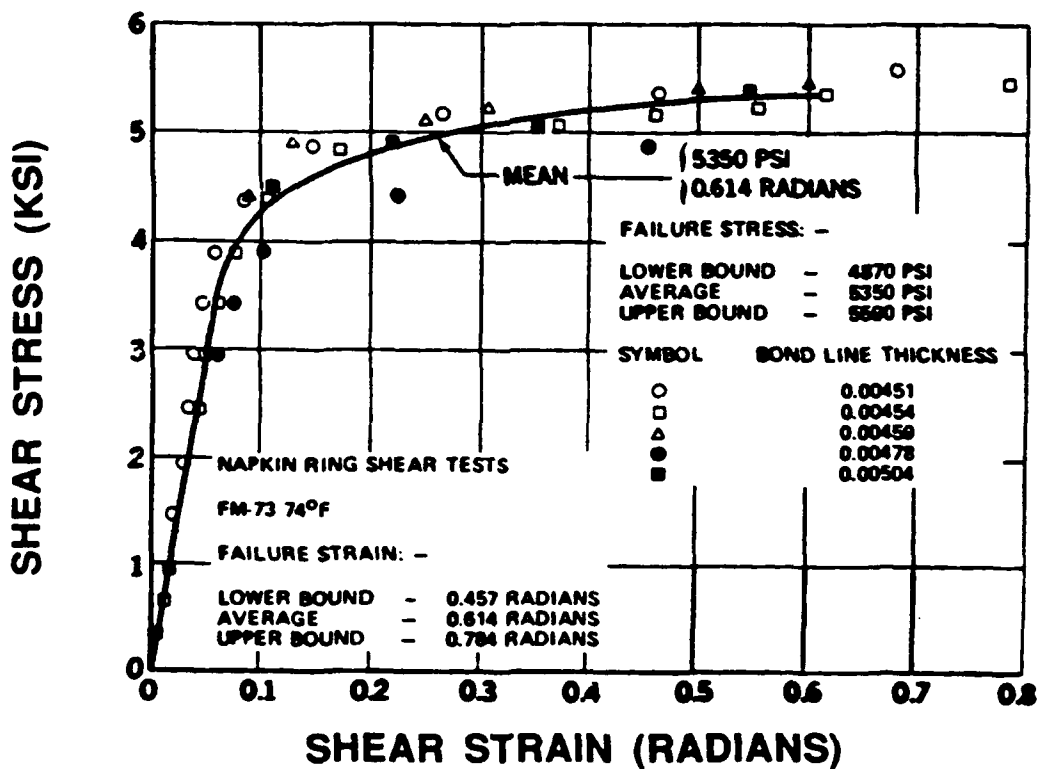


Figure 2-28. Shear stress-strain curve of FM-73 adhesive obtained using napkin ring tests.

respectively. Equation (3) is true for isotropic materials.

**$G_{IIC}$  and  $G_{IIIC}$ .** The mode II critical strain energy release rate for FM-300K, FM-300 and EA-9321 adhesives has been measured as a function of temperature by Russell [2-26] and plotted in Figure 2-29. The  $G_{IIC}$  for the first adhesive increases as temperature increases at low temperature. For temperature higher than room temperature,  $G_{IIC}$  decreases. The  $G_{IIC}$  values for the other two adhesives increase as temperature increases from  $-50^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ . A very limited number of results for  $G_{IIC}$  and  $G_{IIIC}$  for Solithane 113 were reported by Anderson et al. [2-35] and [2-24].

### 2.3.3 Normal Versus Shear Stress-Strain Behaviors

Shear stress-strain curves of adhesives are normally much more nonlinear than their normal components. For instance, Figure 2-30 shows the comparison of the normal [2-19] and shear [2-36] stress-strain curves for Metlbond 1113 adhesive. One exception to this common behavior is AF-126-2 adhesive. Figure 2-31 shows that the extensional component [2-37] is more nonlinear than the shear component [2-38]. No other experimental data have shown or confirmed this unusual characteristic.

### 2.3.4 Adherend Thickness Effects

In 1977, Guess et al. [2-39] conducted tests with EC 2214 R paste adhesive and FM 123-5 film adhesive using thick adherend and standard lap shear tests (ASTM D 1002). Three different adhesive thicknesses (0.127, 0.254 and 0.508 mm) and four adherend thicknesses (0.127, 6.35, 12.7 and 25.4 mm) were tested. The result, Figure 2-32, shows that shear strengths only change slightly when thick adherend lap shear specimens with different thicknesses were used. However, the shear strengths obtained from thin adherend single lap shear tests are less than half (EC 2214 R) of those obtained using the thick adherend lap shear tests. Thin adherend single lap shear tests tend to give lower strength values because of eccentricity, high stress concentrations, introduction of a mixed-mode loading, etc. Figure 2-32 also reveals that a thicker adhesive only slightly reduces the lap shear strength. This agrees with the result reported by Renton and Vinson [2-40]. Unfortunately, the former authors did not report adhesive moduli. Therefore, the peculiar thickness effect of adhesive reported in [2-31] cannot be examined.

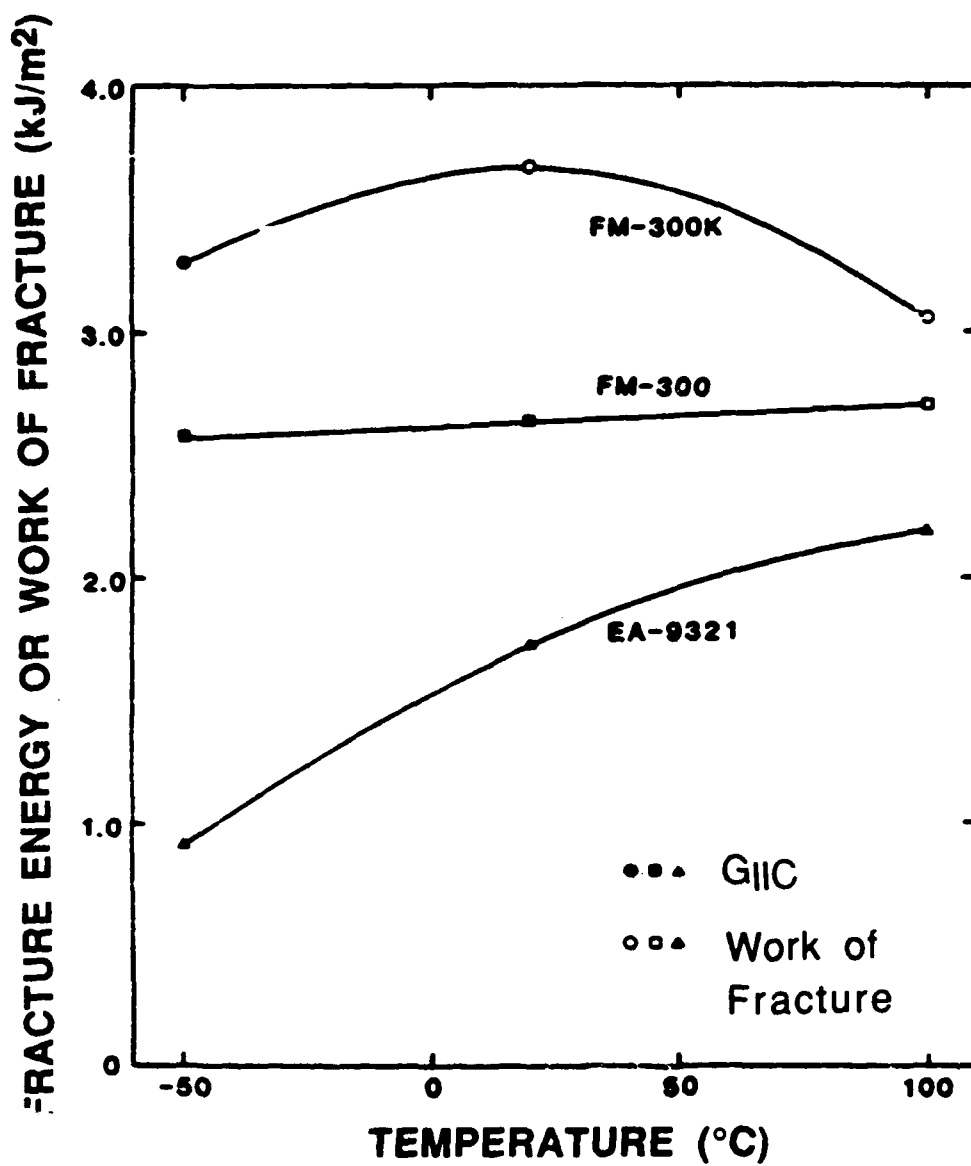


Figure 2-29. Effect of temperature on GIIIC values of adhesives.

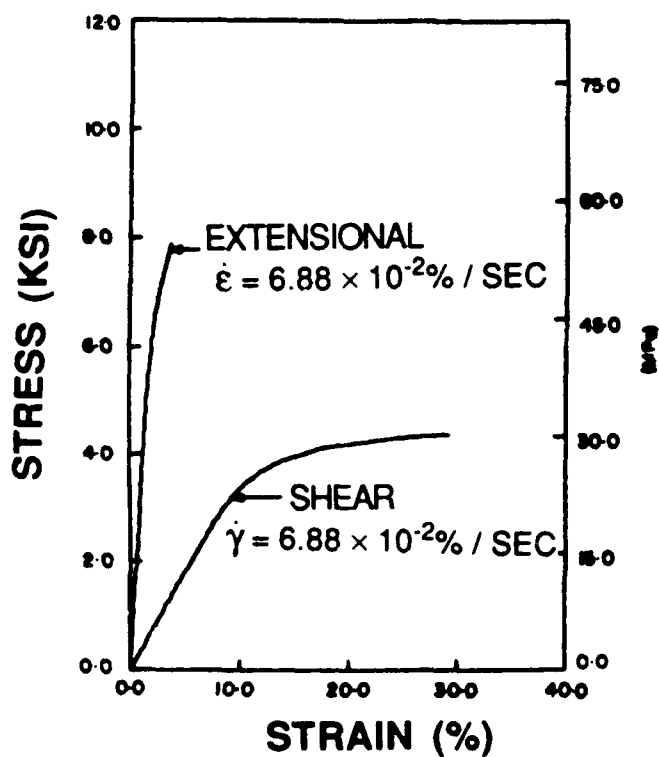


Figure 2-30. Stress-strain curves of Metlbond 1113 adhesive.

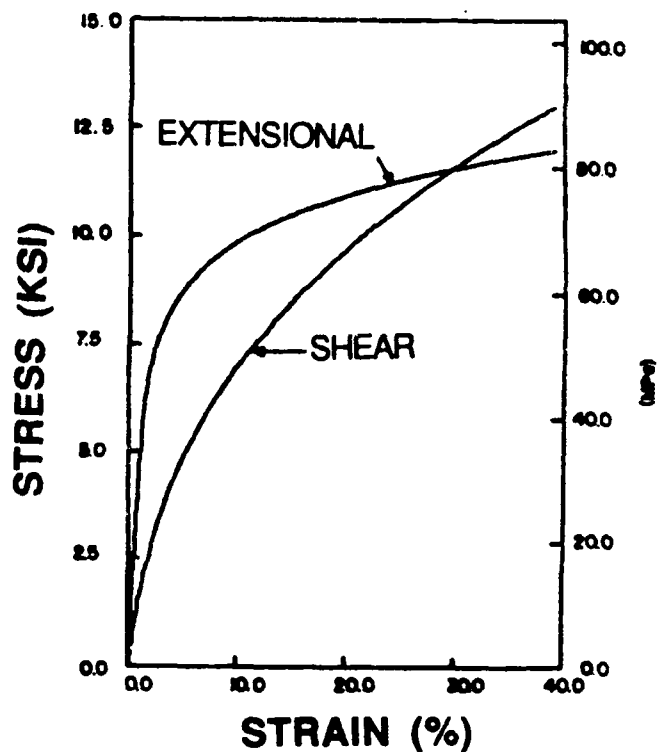


Figure 2-31. Stress-strain curves of AF-126-2 adhesive.

### **2.3.5 Moisture Effects**

Recently, in 1988, Jurf [2-41] studied the effects of moisture on the FM 73M and FM 300M adhesives using a thick adherend lap shear test. He concluded that moisture has no effect on adhesive modulus at room temperature but has significant effects at elevated temperature for these two adhesives, Figure 2-33. The shear modulus-temperature relation for FM 73M is basically the same as that for FM 300M. The shear strength of these adhesives was also reduced significantly due to increase in moisture content.

### **2.3.6 Creep/Stress Relaxation Properties**

Extremely few studies have been conducted in the area of creep and stress relaxation properties of adhesives. In 1975, Brinson et al. [2-19] tested Metlbond 1113 (Figure 2-34) and Metlbond 1113-2 (Figure 2-35). The stress relaxations are significant after only 1 minute of applied constant strain. Beyond 1 minute, stress relaxation was small. Another effort in this area was presented by Seago [2-42]. The author tested 13 adhesives with different primers, surface preparation, cure cycles and carriers. The result showed large difference in cyclic time to failure among the adhesive systems.

### **2.3.7 Effects of Cure Temperature and Time**

Sancaktar, et al. [2-43] used flat dog bone specimens to study the effects of curing time, temperature, and cool down rate on tensile strength of Metlbond 1113-2 and Metlbond 1113 adhesives. Figure 2-36 shows that tensile strength decreases if curing time was less than 120 minutes. Rapid cool-down reduced tensile strength of these adhesives by 5-15%.

## **2.4 JOINING METHODS FOR BONDED JOINTS**

There are five basic types of bonded joints in composites: (1) single lap joints; (2) double lap joints; (3) strap joints; (4) stepped lap joints; and (5) scarf joints [2-44] to [2-47]. Each type of joint contains several variations as shown in Figure 2-37.

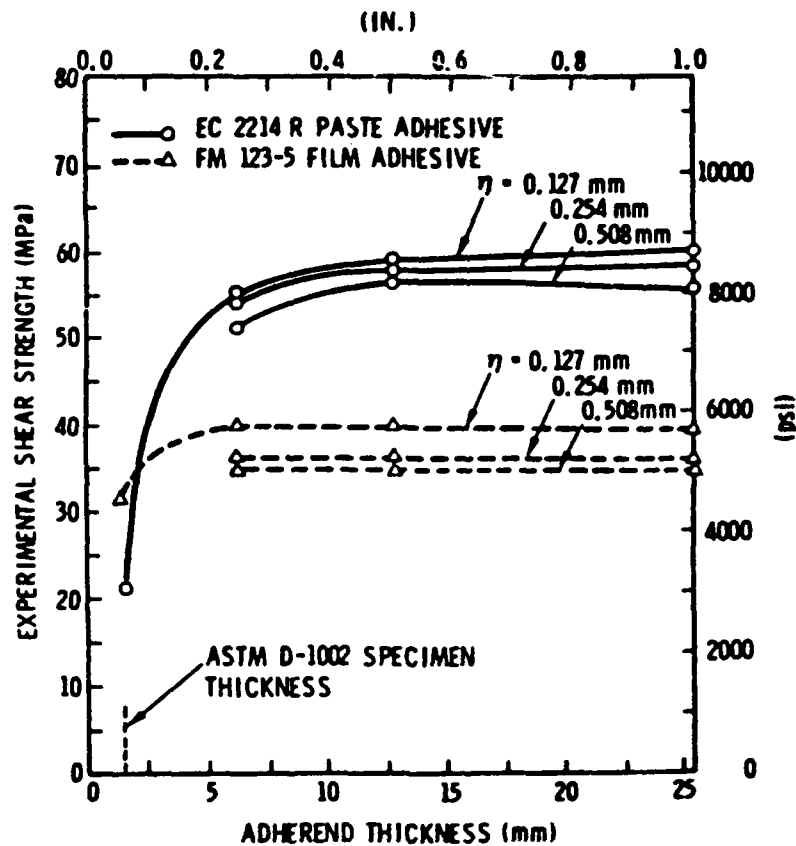


Figure 2-32. Effects of adherend and adhesive thicknesses of lap shear strength of adhesives.

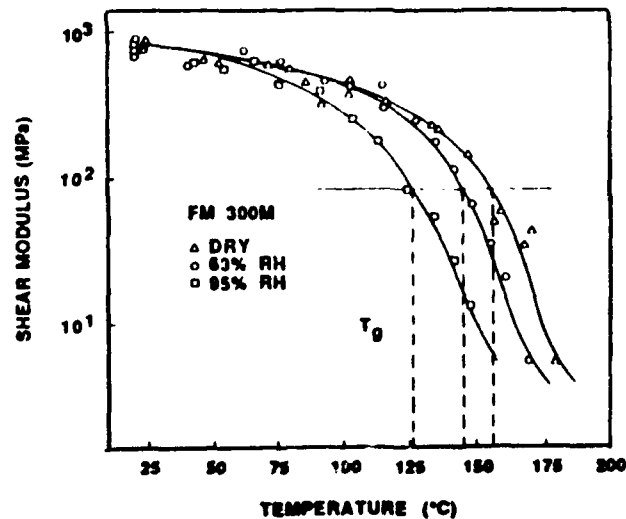


Figure 2-33. Effects of moisture and temperature on shear modulus of FM-300M adhesive.

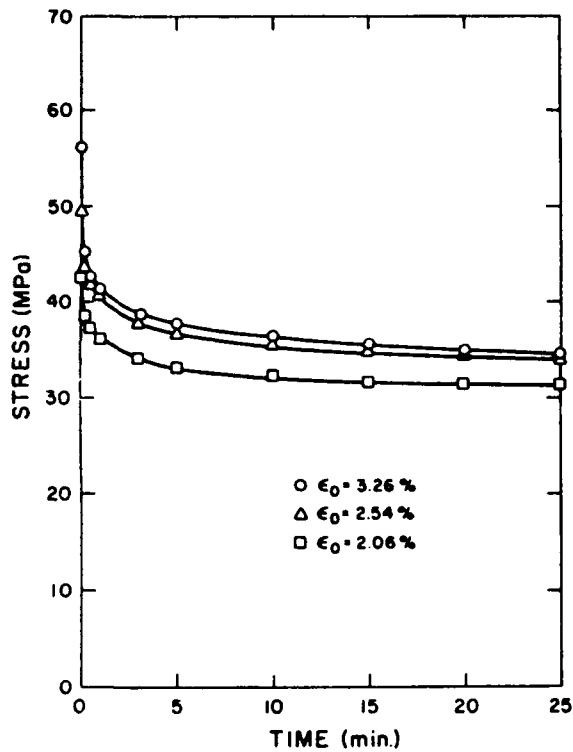


Figure 2-34. Stress Relaxation of Metlbond 1113.

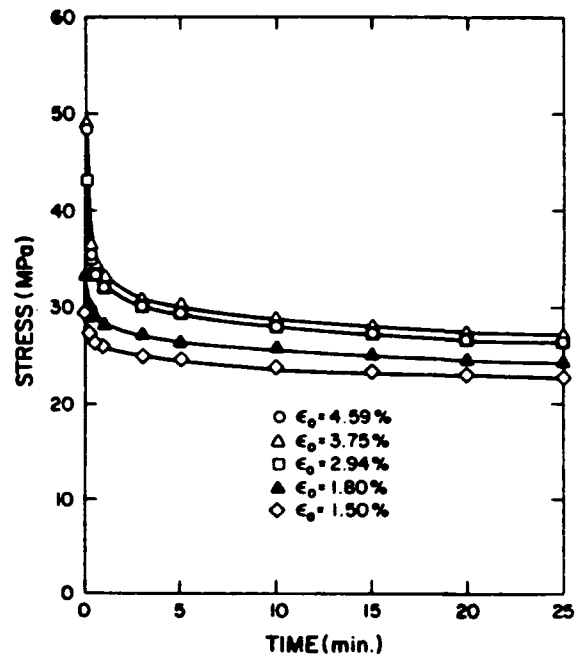


Figure 2-35. Stress Relaxation of Metlbond 1113-2.

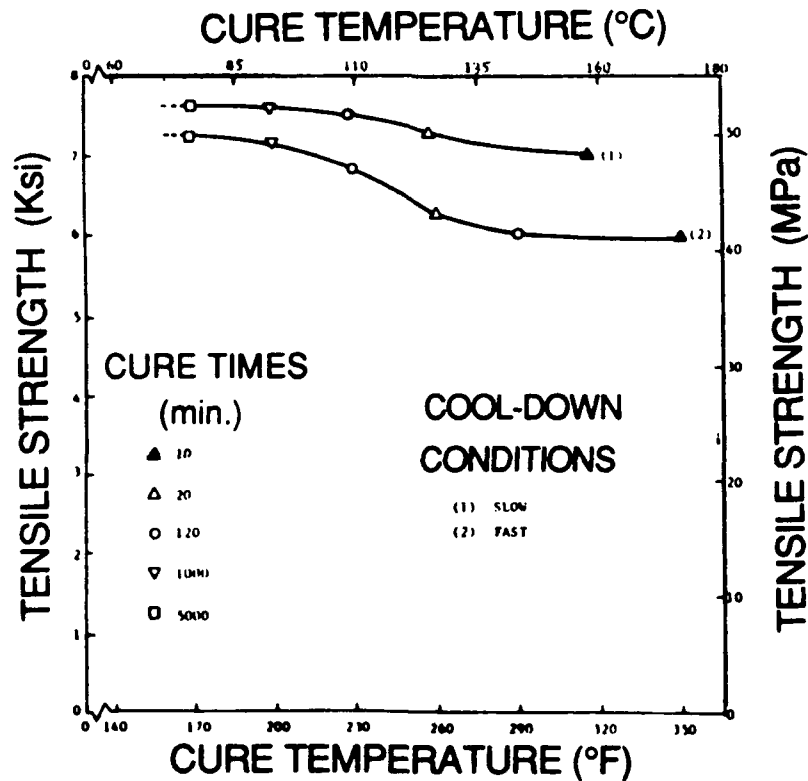


Figure 2-36. Effects of curing time and cool-down rate on tensile strength of Metlbond 1113-2 adhesive.

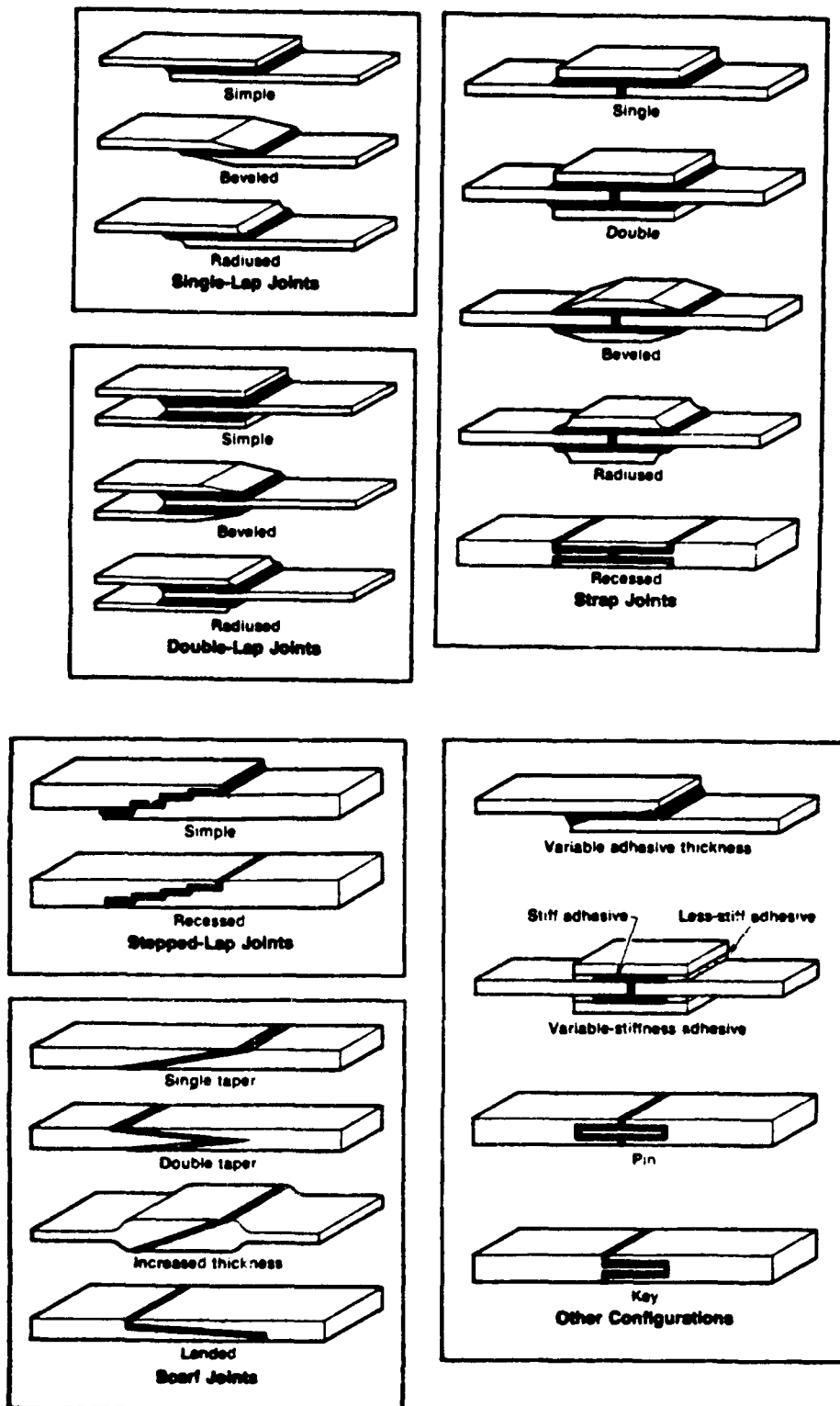


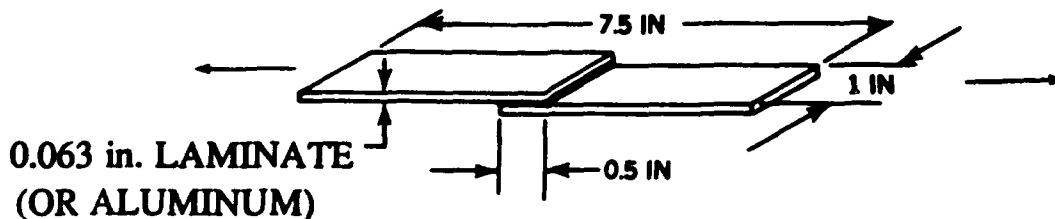
Figure 2-37. Variations of bonded Joints.

## 2.5 LAP SHEAR TESTING

The American Society for Testing and Materials has adopted the single lap shear specimen, Figure 2-38 (ASTM D 1002), to evaluate lap shear properties of adhesively bonded joints. The stress analysis presented in Ref. [2-48] along the bondlines of single and double lap joints showed that adhesives were subjected to mixed-mode loading of nearly equal magnitude. Therefore, *this type of bonded joint cannot be used as a characterization method for adhesives. Rather, it should be treated as a quality control test.* The mechanical properties of structural adhesives in bulk form normally do not directly correlate to the properties in bonded form. The thermal residual stresses due to the curing process depend on the adhesive as well as on the adherend materials.

## 2.6. LAP SHEAR TESTING RESULTS

Experimental data for single lap shear testing of composite materials are extensive. Some typical results will be discussed in the following paragraphs.



$$L/t \text{ (length of overlap to adherend thickness)} = 7.9$$

**Figure 2-38. Single lap shear specimen (ASTM D 1002).**

**Surface Preparation.** The importance of surface treatment on the lap shear strength of composites has been studied by a number of engineers, [2-49] through [2-56]. Wu [2-49] showed that the lap shear strength of thermoplastic composites with adhesive FM-300 and a Kevlar peel ply was approximately twice as high as that treated with Corona. Bonazza [2-50] showed that grit blasting followed by flame treatment yields lap shear strength about three times as high as that with the Corona treatment, Figure 2-39. Jennings [2-52] also showed that specimens with a sandblasted surface preparation result in lap shear strengths double those prepared with a polished surface, Figure 2-40.

**Environmental Conditions.** Kerr [2-57] has studied the Uralane X-87174A/B, Epibond X-87152A/B and Epibond A/B using the ASTM D 1002 test method with aluminum adherends. The environmental conditions included elevated temperature, salt spray, fluid immersion in isopropyl alcohol, gasoline and distilled water. Kilbane and McKown [2-58] have investigated the lap shear strength of XC-3700, AF-126-2 and AF-127-3 adhesives with 7075-T6 aluminum adherends. The XC-3700 adhesive is unique in that it is powder form whereas the last two are film adhesives. The authors showed that the lap shear strength of XC-3700 is just slightly less than those of AF-126-2 and AF-127-3. May [2-59] has tested and compared the lap shear strengths of Reliabond 711, American Cynamid FM 123-2, B. F. Goodrich 717 and FR 7030 adhesives per the ASTM D1002 standard. The environmental conditions included fluid exposure in hydraulic oil and jet engine oil, as well as an exfoliation corrosion test. The results show that two of the adhesives, American Cynamid FM 123-2 and FR 7030, have lap shear strengths ranging from 5.1 to 5.5 ksi after immersed the standard finger specimens in MIL-H-5606 hydraulic oil and in MIL-J-5624 jet engine fuel for seven days. These values are only slightly lower than the control shear strengths between 5.2 and 5.5 ksi. Additional testing results due to environmental conditions can be found in Refs. [2-60] through [2-62].

**Moisture Problems.** In 1982, Myhre, Labor and Aker [2-63] addressed the moisture problem in bonded joints of advanced composite structures. The authors compared the lap shear strength of several adhesives under wet and elevated temperature conditions. The loading conditions included static and fatigue. It was found that moisture has significant effects on the lap shear strength of adhesives. For instance, the lap shear strength of FM-73M adhesive at 100° C under dry conditions is two to three times higher than that at a wet

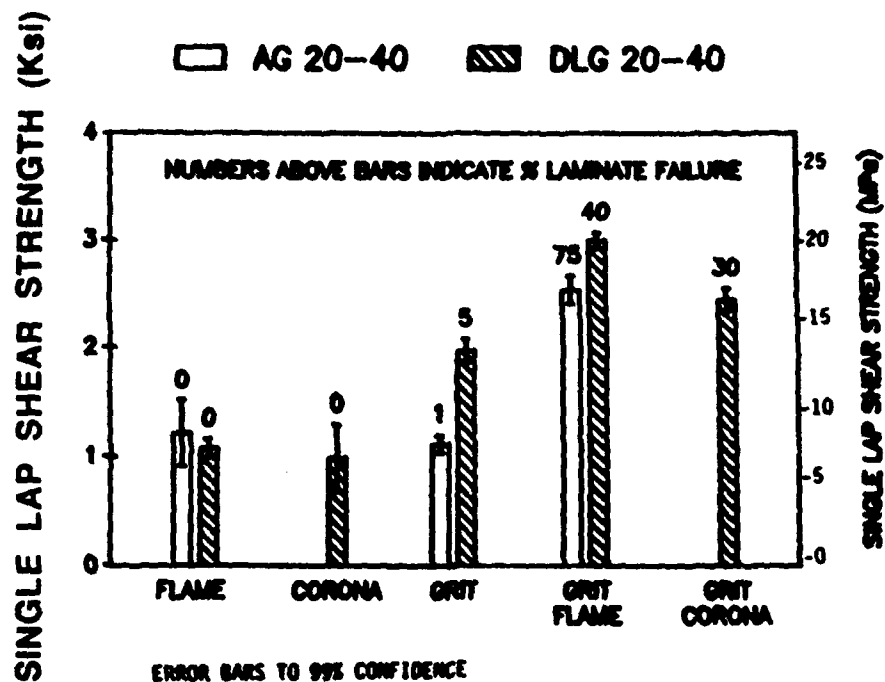


Figure 2-39. Effects of surface preparation on single lap shear strength.

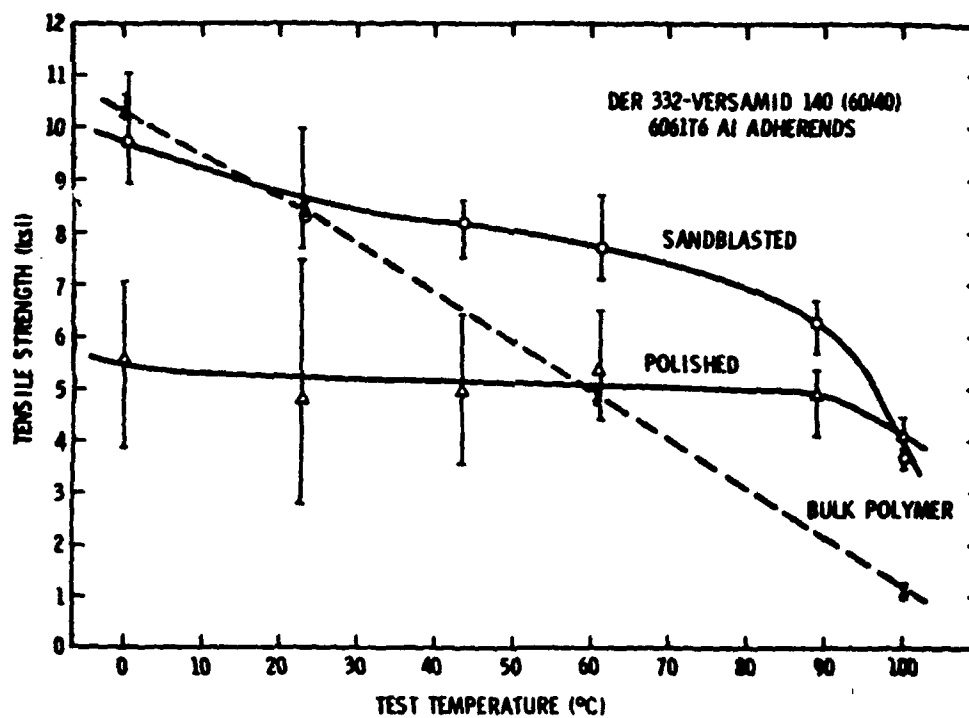
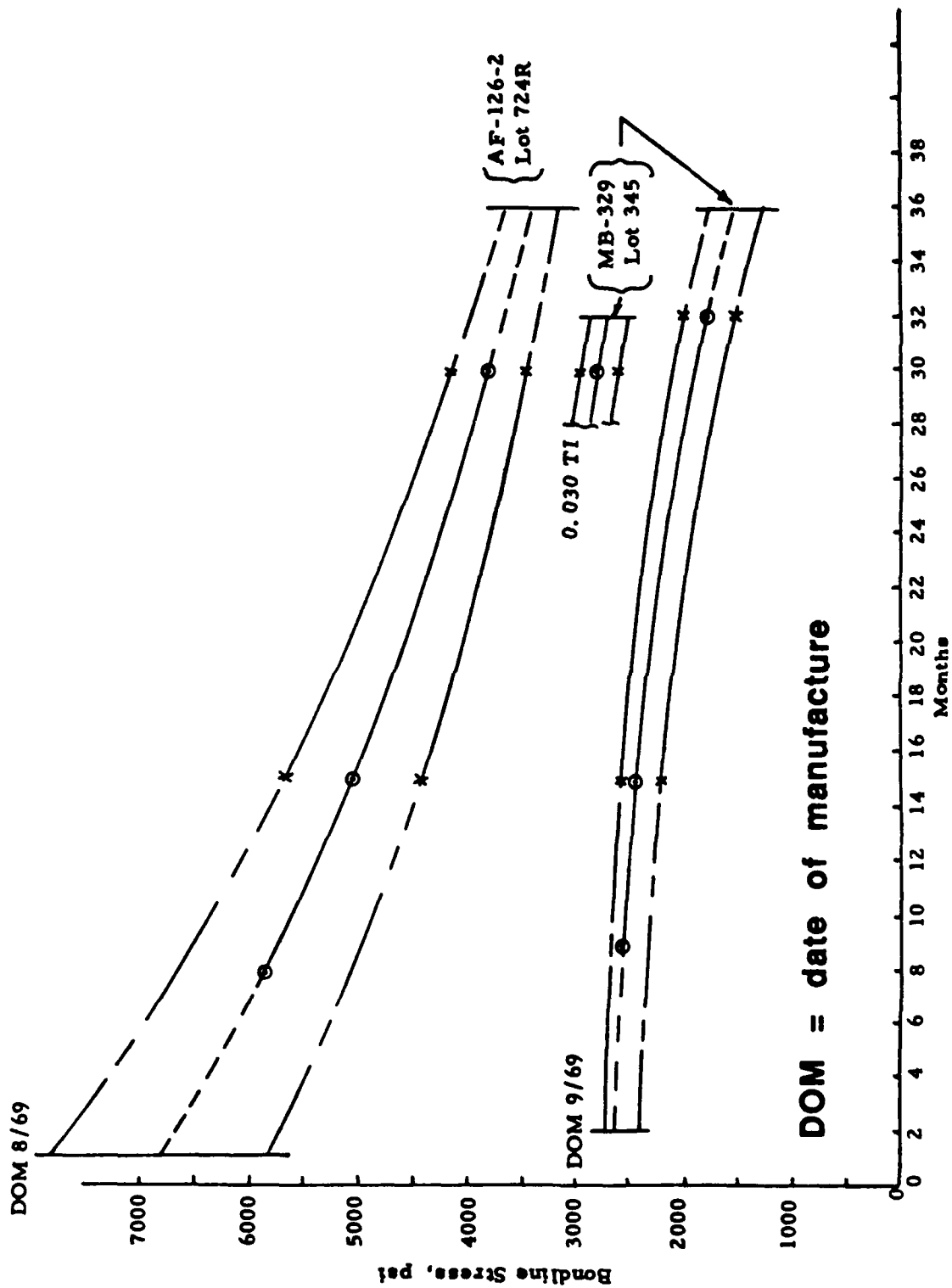


Figure 2-40. Effects of surface preparation and temperature on single lap shear strength.

condition. The data presented by Kiger and Myhre [2-64] show that the lap shear strength of the adhesive FM-400 is not affected by moisture at temperatures up to 140° C while it decreases abruptly beyond 50° C for FM-73M [2-63]. This suggests that adhesive FM-400 is moisture resistant. A moisture resistant adhesive is very useful for structural repair because there are many situations in which moisture is difficult to eliminate, especially in the case of damaged composite laminates or damaged honeycomb structures in the field environment. However, FM 400 is a high temperature system not well-adapted to repair. The data in Ref. [2-65] show that the fatigue strength of FM-73M adhesive is slightly lower than EA-9628, and they both decrease tremendously as the moisture content increases. On the other hand, the fatigue strength of 3M adhesive AF-163-2 is only decreased slightly with moisture content up to 70%. Therefore, AF-163-2 is also a moisture resistant adhesive besides FM-400. The T-peel and lap shear strength of FM-73 and FM-300K in the presence of moisture were investigated by Dodiuk et al. [2-66]. The authors found that the T-peel strength values of FM-73 and FM-300K decreased by 27 and 54%, respectively, with 0.6% moisture content by weight. After the moisture was removed by a drying method they proposed (2.5 hours at 3-5 mm Hg vacuum), the room temperature lap shear strength of FM-73 increased by 11-12%. At 105° C, the lap shear strength values of FM-73 and FM-300K increased by 47 and 25%, respectively, after the moisture was removed.

***Cryogenic and Elevated Temperature Applications.*** The adhesive bonding strength of PEEK/IM-6 composites was studied for applications at cryogenic and elevated temperature conditions [2-67]. The screening test was performed using 24 adhesives and 6 different surface preparations. The effect of moisture was also studied. FM 300 and EA 9394 were recommended for cryogenic (-452° F) and elevated temperature (250° F) applications. Although these adhesives have lower bonding strengths than several other adhesives at room temperature, their strengths are not affected by moisture and the degradation in strength at elevated temperature is much less severe than the other adhesives.

***Other Adhesive Lap Shear Properties.*** The effect of storage time on the lap shear strength of adhesives was reported by Grimes [2-68], Figure 2-



**Figure 2-41. Effect of storage life on lap shear strength of AF-126-2 and MB-329 adhesives.**

41, and Tanner [2-56]. Here, the storage time indicates the time after the adhesive was made and before it was used to prepare a bonded joint. The result indicates that the lap shear strength value degrades faster as a function of storage time for AF-126-2 than for MB-329.

Behm and Clark [2-69] have studied two room temperature cured adhesives: CIBA-GEIGY LNH 263-29 and LMH 262-48. These two are toughened epoxy adhesives. They have good toughness and require no special safety handling procedures. The latter has good retention of lap shear strength over a wide temperature range. Its lap shear strength under the environmental conditions of fluid immersion, humidity exposure and thermal aging were also reported. Lap shear strengths of many other adhesives were reported in Refs. [2-69] through [2-74].

Another issue that has been studied is out time (shop life) of adhesives prior to use and the effects on strength of temperature and humidity. After six weeks of open time May [59] reported that the lap shear strength of FR 7030 is as good as its initial value while the American Cynamid FM 123-2 degrades slightly.

## **2.7. DATABASE**

Two computer programs were created using Microsoft "Excel." One, called "Bulk-adhesive," stores adhesive properties as shown in Appendix B-1. Another, "Adhesive Lap-Joints," stores lap shear strength of composites as shown in Appendix B-2. Appendix B-1 and Appendix B-2 contain 23 columns (from A to W) and 16 columns (from A to P), respectively. If one clicks the column number at any column and goes to "sort" under the manual "Data," then he can rank the data in either ascending or descending order.

## **2.8. SUMMARY AND CONCLUSION**

Existing adhesive properties and lap shear strengths of composites are collected using the same format. The test methods that were used to generate these data and other commonly used testing methods in this area are discussed with many illustrations. Then the parameters that affect the adhesives and the lap shear properties are discussed.

The adhesive property results include normal stress-strain curve and strength, shear stress-strain curve and strength, the effects of curing temperature, time and cool down rate, creep properties, and thickness effects on the adhesive properties, etc. All the testing methods involve more than one stress component in the test section of the specimen. Therefore, stress analysis must be performed to obtain accurate data interpretation. Apparent experimental results can be misleading without proper data interpretation. For instance, the apparent modulus and strength measured by lap shear tests depend on the thickness of the adherend. This is because the value of stress concentration is different for lap shear tests with different thickness of adherend.

Single and double lap shear configurations have been used extensively in structural applications. Stress analysis has shown that adhesives were subjected to mixed-mode loading of nearly equal magnitude along the bondline. Therefore, these types of bonded joints cannot be used to characterize adhesives. Rather, they should be treated as a quality control test. Parametric studies have shown that surface preparation, environmental conditions, and moisture can change the lap shear strengths tremendously (a few hundred percent).

## REFERENCES

- 2-1. Olson, A. J and H. R. Pearson, "Complex Adhesive Bonded Assemblies," Symposium on Processing for Adhesives Bonded Structures at Stevens Institute of Technology, August 23-25, 1972.
- 2-2. Black, J. B., B. R. Fox and K. A. Linton, "Development of Composites Technology for Joints and Cutouts in Fuselage Structure of Large Transport Aircraft," Semiannual Technical Report, Douglas Aircraft Company, April 1985.
- 2-3. Kong, S. J., "Design of Highly Loaded Composite Joints and Attachments for Tail Structure," Northrop Corporation report No. NADC-81216-60, August 1981.
- 2-4. Proceeding of Symposium for Processing for Adhesives Bonded Structures, Vols. I and II, Stevens Institute of Technology, August 23-25, 1972.
- 2-5. Horton, R. E., J. E. McCarty, et al., "Adhesive Bonded Aerospace Structures Standardized Repair Handbook," Air Force Technical Report AFML-TR-77-206, 1978.

- 2-6. Wegman, R. F., "Repair of Damage to Secondary Aircraft Structure of Advanced Composite Material," Plastic Report R51, October 1983.
- 2-7. Cochran, R. C., T. M. Donnellan, J. G. Williams, J. J. Katilaus and N. Nemeroff, "An Adhesive for Field Repair of Composites," Report No. NADC-88072-60, June 1988.
- 2-8. Matthews, F. L., P. F. Kilty and E. W. Godwin, "A Review of the Strength of Joints in Fibre-Reinforced Plastics, Part 2. Adhesively Bonded Joints," Composites, January 1982, pp. 29-37.
- 2-9. Standard Test Method for Shear Strength and Shear Modulus of Structural Adhesives, ASTM Standard E229-70, 1970.
- 2-10. Standard Test Method for Strength Properties of Adhesive Bonds in Shear by Compressive Loading, ASTM Standard D 905-86, 1986.
- 2-11. Mall, S., W. S. Johnson and R. A. Everett, "Cyclic Debonding of Adhesively Bonded Composites," NASA Technical Memo. 84577, November 1982.
- 2-12. Kinloch, A. J., Developments in Adhesives-2, Applied Science Publishers, London, 1981, Chp. 3, pp. 83-124.
- 2-13. Weissberg, V. and M. Arcan, "A Uniform Pure Shear Testing Specimen for Adhesive Characterization," Adhesively Bonded Joints: Testing, Analysis, and Design, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 28-38.
- 2-14. Sancaktar, E., H. Jozavi, J. Baldwin and J. Tang, "Elastoplastic Fracture Behavior of Structural Adhesives Under Monotonic Loading," J. Adhesion, 1987, Vol. 23, pp. 233-262.
- 2-15. Bascom, W. D. and C. O. Timmons and R. L. Jones, J. Materials Sciences, Vol. 10, 1975, p. 1037.
- 2-16. Ramberg, W. and Osgood, W. R., "Description of Stress-Strain Curves by Three Parameters," NACA TN 902, April 1943.
- 2-17. Brinson, H. F. and DasGupta, A., "The Strain Rate Behavior of Ductile Polymers," SESA Paper No. 2256, presented at the SESA Fall Meeting, Indianapolis In, October 16-19, 1973.

- 2-18. Moreno-Villalobos, M., P. Czarnocki and K. Piekarski, "Properties of Adhesives and Their Applications," *J. Adhesion*, 1986, Vol. 19, 79-87.
- 2-19. Brinson, H. F, M. P. Renieri and C. T. Herakovich, "Rate and Time Dependent Failure of Structural Adhesives," *Fracture Mechanics of Composites*, ASTM STP 593, American Society for Testing and Materials, 1975, pp. 177-199.
- 2-20. Jeandrau, J. P., "Intrinsic Mechanical Characterization of Structural Adhesives," *Int. J. Adhesion and Adhesives*, Vol. 6, No. 4, October 1986, pp. 22-31.
- 2-21. Jangblad, D., P. Gradin, and T. Stenstrom, "Determination and Verification of Elastic Parameters for Adhesives," *Adhesively Bonded Joints: Testing, analysis, and Design*, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 54-68.
- 2-22. Messer, A. M., "Stress Distribution in Poker Chip Tensile Specimens," *Bulletin of Working Group on Mechanical Behavior*, CPIA Publication 27, chemical Propulsion Information Agency, 1963.
- 2-23. Anderson, G. P., K. L. DeVries and G. Sharon, "Evaluation of Tensile Tests for Adhesive Bonds," *Delamination and Debonding of Materials*, ASTM STP 876, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1985, pp. 115-134.
- 2-24. Anderson, G. P. and K. L. Devries, "Predicting Bond Strength," *J. Adhesion*, Vol. 23, 1987, pp. 289-302.
- 2-25. Anderson, G. P., S. Chandapeta, and K. L. Devries, "Effect of Removing Eccentricity from Button Tensile Adhesion Tests," *Adhesively Bonded Joints: Testing, Analysis, and Design*, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 5-12.
- 2-26. Russell, A. J., "A Damage Tolerance Assessment of Bonded Repairs to CF-18 Composite Components, Part I: Adhesive Properties," *DREP TM-88-25* December 1988.
- 2-27. Mall, S. and K. T. Yun, "Effect of Adhesive Ductility on Cyclic Debond Mechanism in Composite-to-Composite Bonded Joints," *J. Adhesion*, Vol. 23, 1987, pp. 215-231.
- 2-28. Mostovoy, S. and E. J. Ripling, "Flaw Tolerance of a Number of Commercial and Experimental Adhesives," *Adhesion Science and Technology*, American Chemical Society Macromolecular Symposium on Science and Technology of Adhesion, Philadelphia PA, 1975, Ed. L. H. Lee, Plenum Press, New York, pp.513-562.

- 2-29. Kinloch A. J., W. A. Dukes and R. A. Gledhill, "Durability of Adhesive Joints," Adhesion Science and Technology, American Chemical Society Macromolecular Symposium on Science and Technology of Adhesion, Philadelphia PA, 1975, Ed. L. H. Lee, Plenum Press, New York, pp.597-618.
- 2-30. Kuenzi, E. W. and G. H. Stevens, "Determination of Mechanical Properties of Adhesives for Use in the Design of Bonded Joints," U. S. Forest Service Research Note, Forest Products Laboratory, Madison WI, October 1963.
- 2-31. Renton, J. W. and J. R. Vinson, "On the Behavior of Bonded Joints in Composite Material Structures," Engineering Fracture Mechanics, Vol. 7, 1975, pp. 41-60.
- 2-32. Post, D., R. Czarnek, J. D. Wood, and D. Joh, "Deformations and Strains in a Thick Adherend Lap Joint," Adhesively Bonded Joints: Testing , Analysis, and Design, ASTM STP 981, W. S. Johnson, Ed., American society for Testing and Materials, Philadelphia PA, 1988, pp. 107-118.
- 2-33. Miller, J. M., J. L. Hammill and K. E. Luyk, "Understanding Effects of Adhesive Ductility and Bondline Geometry on Tube-and-Socket joint Performance," Adhesively Bonded Joints: Testing, Analysis, and Design, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 252-263.
- 2-34. Primary Adhesively Bonded Structure Technology (PABST), Design Handbook for Adhesive Bonding, Air Force Technical Report AFFDL-TR-79-3129, January 1979.
- 2-35. Anderson, G. P., K. L. Devries and M. L. Williams, "The Influence of Loading Direction Upon the Character of Adhesive Debonding," J. Colloid and Interface Science, Vol. 47, No. 3, June 1974, pp. 600-609.
- 2-36. Sancaktar, E., "Shear Behavior of a Viscoelastic Structural Adhesive," Ph. D Dissertation, Virginia Polytechnic Institute and State University.
- 2-37. Humphreys, E. A. and C. T. Herakovich, "Nonlinear Analysis of Bonded Joints with Thermal Effects," NASA-CR-153263, 1977.
- 2-38. Birchfield, E. B., R. T. Cole and L. F. Impellizzeri, "Reliability of Step-Lap Bonded Joints," AFFDL-TR-72-26. April 1975.
- 2-39. Guess, T. R., R. E. Allred and F. P. Gerstle, Jr., "Comparison of Lap Shear Test Specimens," J. Testing and Evaluation, JTEVA, Vol. 5, No. 3, March 1977, pp. 84-93.

- 2-40. Renton, W. J. and J. R. Vinson, "The Analysis and Design of Composite Material Bonded Joints under Static and Fatigue Loadings," AFOSR Scientific Report TR-73-1627, August 1973.
- 2-41. Jurf, R. A., "Environmental Effects on Fracture of Adhesively Bonded Joints," Adhesively Bonded Joints: Testing, Analysis, and Design, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 276-288.
- 2-42. Seago, R., "Cyclic Creep Studies of Adhesives," 1st National SAMPE Technical Conference, Seattle, Washington, September 9-11, 1969, pp. 135-143.
- 2-43. Sancaktar, E., H. Jozavi and R. M. Klein, "The Effects of Cure Temperature and Time on the Bulk Tensile Properties of a Structural Adhesive," J. Adhesion, Vol. 15, 1983, pp. 241-264.
- 2-44. Dreger, D. R., "Design Guidelines for Joining Advanced Composites," Machine Design, Vol. 52, May 1980, pp. 9-13.
- 2-45. Renton, W. J., J. Pajerowski and J. R. Vinson, "On Improvement in Structural Efficiency of Single-Lap Bonded Joints," Advances in Joining Technology, Proceedings of the 4th Army Materials Technology Conference, Boston MA., September 16-19, 1975, Eds. J. J. Burke, A. E. Gorum and A. Tarpinian.
- 2-46. Hart-Smith, L. J., "Joints," Engineering Materials Handbook, Vol. 1, Composites, ASM International, 1987, pp. 479-495.
- 2-47. Dastin, S. J., "Joining and Machining Techniques," Handbook of Composites, Ed. G. Lubin, Van Nostrand Reinhold Co., 1969.
- 2-48. Long, R. S., "Static Strength of Adhesively Bonded ARALL-1 Joints," J. Composite Materials, Vol. 25, 1991, pp. 391-415.
- 2-49. Wu, S. I., "Adhesive Bonding of Thermoplastic Composites, 2. Surface Treatment Study," 35th Int. SAMPE Symposium, April 2-5, 1990, pp. 846-858.
- 2-50. Bonazza, B. R., "Adhesive Bonding of Improved Polyphenylene Sulfide Thermoplastic Composites," 35th Int. SAMPE Symposium, April 2-5, 1990, pp. 859-870.
- 2-51. Maguire, D. M., "Joining Thermoplastic Composites," SAMPE Journal, Vol. 25, No. 1, pp. 11-14, 1989.
- 2-52. Jennings, C. W., "Surface Preparation for Adhesive Bonding," Proceedings of Symposium for Processing for Adhesives Bonded Structures, August 23-25, 1972, Hoboken, New Jersey, pp. 82-100.

- 2-53. Rogger, J. S., "The Importance of Preparation and Control in the Repair of Fibre Reinforced Plastics," *Composite Structures*, Vol. 6, 1986, pp. 165-182.
- 2-54. Parker, B. M. and R. M. Waghorne, "Surface Pretreatment of Carbon Fibre-Reinforced Composites for Adhesive Bonding," *Composites*, July 1982, pp. 280-288.
- 2-55. Stone, R. H., "Field-Level Repair Materials and Processes," 28th National SAMPE symposium, April 12-14, 1983, pp. 210-222.
- 2-56. Tanner, W. C., "Manufacturing Processes with Adhesives Bonding," *Proceedings of Symposium for Processing for Adhesives Bonded Structures*, August 23-25, 1972, Hoboken, New Jersey, pp. 1-33.
- 2-57. Kerr, A. B., "New Directions in Aircraft Adhesives and Sandwich Structural Materials," *SAMPE Technical Conference Proceedings, Aerospace Adhesives and Elastomers*, Vol. 2, Oct. 6-8, 1970, Dallas, Texas, pp. 1-8.
- 2-58. Kilbane, G. J. and A. G. McKown, "Powder Form Structural Adhesives," *SAMPE Technical Conference Proceedings, Aerospace Adhesives and Elastomers*, Vol. 2, Oct. 6-8, 1970, Dallas, Texas, pp. 13-21.
- 2-59. May, L. C., "Evaluation of Low-Temperature Curing, Long-Open-Time Adhesives," *SAMPE Technical Conference Proceedings, Aerospace Adhesives and Elastomers*, Vol. 2, Oct. 6-8, 1970, Dallas, Texas, pp. 89-93.
- 2-60. Pitrone, L. R. and S. R. Brown, "Environmental Durability of Adhesively Bonded Joints," *Adhesively Bonded Joints: Testing, Analysis, and Design*, ASTM STP 981, W. S. Johnson, Ed., American Society for Testing and Materials, Philadelphia PA, 1988, pp. 289-303.
- 2-61. Askins, D. R. and A. Konopinski, "The Effect of Environmental Aging and Rapid Heating (Thermal Spikes) on the Behavior of Adhesively Bonded Joints," 21st Int. SAMPE Technical Conference, September 25-28, 1989, pp. 249-263.
- 2-62. Aponyi, T. J., "The Effects of Environmental Exposure on Strain Properties of AF-A-3639 Adhesive Bonded Joints," *Air Force Technical Report AFML-TR-73-104*, August 1973.
- 2-63. Myhre, S. H., J. D. Labor and S. C. Aker, "Moisture Problems in Advanced Composite Structural Repair," *Composites*, July 1982, pp. 289-297.
- 2-64. Kiger, R. W. and S. H. Myhre, "Large Area Composite Structure Repair," *Second Interim Report, AFFDL-TR-77-121 Northrop Corporation, Aircraft Division*, November 1977.

- 2-65. Thrall, E. W., "Prospects for Bonding Primary Aircraft Structure in the 80's," 25th National SAMPE Symposium and Exhibition, San Diego CA, May 1980.
- 2-66. Dodiuk, H., L. Drori and J. Miller, "The Effect of Moisture Content in Epoxy Film Adhesives on Their Performance. II. T-Peel and 105°C Lap Shear Strength," *J. Adhesion*, Vol. 19, 1985, pp. 1-13.
- 2-67. Goeders, D. C. and J. L. Perry, "Adhesive Bonding PEEK/IM-6 Composite for Cryogenic Applications," Vol. 36, eds. J. Stinson, R. Adsit and F. Gordaninejad, San Diego CA., April 15-18, 1991, pp. 348-361.
- 2-68. Grimes, G. C., L. F. Greimann, T. Wah, G. E. Commerfield, W. R. Blackstone and G. K. Wolfe, "The Development of Nonlinear Analysis Methods for Bonded Joints in Advanced Filamentary Composite Structures," Air Force Technical Report AFFDL-TR-72-97, September 1972.
- 2-69. Behm, D. T. and E. Clark, "High Performance Epoxy Adhesives," *34th International SAMPE Symposium and Exhibition*, Eds., G. A. Zakrzewski, D. Mazenko, S. T. Peters and C. D. Dean, Reno, Nevada, May 8-11, 1989.
- 2-70. Kelly, W. T., "Development of Optimum Joints in Graphite Composites - Carboform Material," *Proceedings of Symposium for Processing for Adhesives Bonded Structures*, August 23-25, 1972, Hoboken, New Jersey, pp. 247-265.
- 2-71. Cichon, M. J., "Repair Adhesives: Development Criteria for Field Level Conditions," *34th Int. SAMPE Symposium*, Vol. 34, eds. G. A. Zakrzewski, D. Mazenko, S. T. Peters and C. D. Dean, Reno, Nevada, May 8-11, 1989, pp. 1052-1066.
- 2-72. Ong, C. L. and S. B. Shen, "Adhesive-Bonded Composite-Patching Repair of Cracked Aircraft Structure" *34th Int. SAMPE Symposium*, Vol. 34, Eds. G. A. Zakrzewski, D. Mazenko, S. T. Peters and C. D. Dean, Reno, Nevada, May 8-11, 1989, pp. 1067-1079.
- 2-73. Askins, D. R. and D. R. Byrge, "Evaluation of 350°F Curing Adhesive Systems on Phosphoric Acid Anodized Aluminum Substrates," Air Force Technical Report AFWAL-TR-86-4039, August 1986.
- 2-74. "Mechanics of Adhesive Bonded Lap-Type Joints: Survey and Review," Technical Documentary Report No. ML TDR-64-298, October 1964.

## Chapter 3

### Lamina Properties

Lamina properties are required for analysis of composite structures. The fiber forms in this report include both unidirectional and woven. The elastic properties of particular interest include: longitudinal modulus ( $E_{11}$ ), transverse modulus ( $E_{22}$ ), in-plane shear modulus ( $G_{12}$ ) and major Poisson's ratio ( $\nu_{12}$ ). The strength properties include: longitudinal tensile strength (X), longitudinal compressive strength (X'), transverse tensile strength (Y), transverse compressive strength (Y'), and in-plane shear strength (S).

Again, the data reported here were collected from many journals, technical reports from DoD and national laboratories, and materials manufacturers. These references are listed below. A database was created using "Excel" software and is given in Appendix C-1 ("Lamina Properties").

#### REFERENCES

- 3-1. Tan, S. C., "A Progressive Failure Model for Composite Laminates Containing Openings," J. Composite Materials, Vol. 25, May 1991, pp. 556-577.
- 3-2. Tan, S. C., "Analysis of Mini-Sandwich Specimen for Compression Test," Proceedings of the 6th Technical Conference of American Society for Composites, Albany, New York, October 7-9, 1991, pp. 681-692.
- 3-3. Flagg, D. L., "Prediction of Tensile Matrix Failure in Composite Laminates," J. Composite Materials, Vol. 19, 1985, pp. 29-50.

- 3-4. Highsmith, A. L. and K. L. Reifsnider, "Stiffness-Reduction Mechanisms in Composite Laminates," *Damage in Composite Materials*, ASTM STP 775, American Society for Testing and Materials, 1982, pp. 103-117.
- 3-5. Pagano, N. J. and H. T. Hahn, "Evaluation of Composite Curing Stresses," *Composite Materials: Testing and Design*, ASTM STP 617, American Society for Testing and Materials, 1977, pp. 317-329.
- 3-6. Tan, S. C., "Tensile and Compressive Notched Strength of PEEK Matrix Composite Laminates," *J. Reinforced Plastics and Composites*, Vol. 6, July 1987, pp. 253-267.
- 3-7. Yoon, K. J. and C. T. Sun, "Characterization of Elastic-Viscoplastic Properties of an AS4/PEEK Thermoplastic Composite," *J. Composite Materials*, Vol. 25, October 1991, pp. 1277-1313.
- 3-8. Henaff-Gardin, C. and M. C. Lafarie-Frenot, "Composites, Vol. 23, No. 2, March 1992, p. 109.
- 3-9. Garbo, S. P. and J. M. Ognowski, "Effect of Variances and Manufacturing Tolerances on the Design Strength and Life of Mechanically Fastened Composite Joints, Vol. 1. Methodology Development and Data Evaluation," Air Force Technical Report AFWAL-TR-81-3041, April 1981.
- 3-10. Cutler, M. B. and R. L. Pinckney, "Static and Fatigue Test Properties for Woven and Nonwoven S-Glass Fibers," USAAVLABS Technical Report 69-9, June 1969.
- 3-11. Chang, F. K. and K. Y. Chang, "Post-Failure Analysis of Bolted Composite Joints in Tension or Shear-Out Mode Failure," *J. Composite Materials*, Vol. 21, September 1987, p. 809.
- 3-12. Serabian, S. M. and D. W. Oplinger, "An Experimental and Finite Element Investigation into the Mechanical Response of 0/90 Pin-Loaded Laminates," *J. Composite Materials*, Vol. 21, July 1987, p. 631.
- 3-13. Hart-Smith, L. J., "Bolted Joints in Graphite-Epoxy Composites," NASA-CR-144899, June 1976.
- 3-14. Poulos, M. Jr., "Manufacturing Technology for Low-Cost Composite Fasteners," Air Force Technical Report AFML-TR-79-4044, June 1979.

- 3-15. Grimes, G. C., L. F. Greimann, T. Wah, G. E. Commerfield, W. R. Blackstone and G. K. Wolfe, "The Development of Nonlinear Analysis Methods for Bonded Joints in Advanced Filamentary Composite Structures," Air Force Technical Report AFFDL-TR-72-97, September 1972.
- 3-16. Ong, C. L., M. F. Sheu and Y. Y. Loiu, "The Repair of Thermoplastic composites after Impact," Proceedings of the 34th Int. SAMPE Symposium, Reno, Nevada, Eds. G. A. Zakrzewski, D. Mazenko, S. T. Peters and C. D. Dean, May 8-11, 1989.
- 3-17. Black, J. B., B. R. Fox and K. A. Linton, "Development of Composites Technology for Joints and Cutouts in Fuselage Structure of Large Transport Aircraft," Technical Report ACEE-34-PR-3507, Douglas Aircraft Company, April 1985.
- 3-18. Kretsis, G. and F. L. Matthews, "The Strength of Bolted Joints in Glass Fibre/Epoxy Laminates," Composites, Vol. 16, No. 2, April 1985, p. 92.
- 3-19. Manufacturer: Fothergill.
- 3-20. Manufacturer: Ciba-Geigy.
- 3-21. Collings, T. A., "On the Bearing Strengths of CFRP Laminates," Composites, July 1982, p. 241.
- 3-22. Silverman, E. M., C. R. Wiacek and R. A. Griese, "Characterization of IM7 Graphite/Thermoplastic Polyetheretherketone (PEEK) for Spacecraft Structural Applications," Composite Materials: Testing and Design (Tenth Volume), ASTM STP 1120, Glenn C. Grimes, Ed., American Society for Testing and Materials, Philadelphia PA, 1992, pp. 118-130.
- 3-23. Liechti, K. M., K. L. Reifsnider, W. W. Stinchcomb and D. A. Ulman, "Cumulative Damage Model for Advanced Composite Materials," Air Force Technical Report AFWAL-TR-82-4094, 1982.
- 3-24. Allen, D. H. and C. E. Harris, "A Thermomechanical Constitutive Theory for Elastic Composites with Distributed Damage-II. Application to Matrix Cracking in Laminated Composites," Int. J. Solids Structures, Vol. 23, No.9, pp. 1319-1338, 1987, p. 1319.
- 3-25. Manufacturer: ICI Composites Inc.
- 3-26. Manufacturer: Hercules Aerospace Co.

3-27. Manufacturer: Ciba-Geigy.

3-28. Greszczuk, L. B., "Application of Four-Point Ring-Twist Test for Determining Shear Modulus of Filamentary Composites," Test Methods and Design Allowables for Fibrous Composites, ASTM STP 734, C. C. Chamis, Ed., American Society for Testing and Materials, 1981, pp. 21-33.

3-29. Lamothe, R. M. and J. Nunes, "Evaluation of Fixturing for Compression Testing of Metal Matrix and Polymeric/Epoxy composites," Compression Testing of Homogeneous Materials and Composites, ASTM STP 808, R. Chait and R. Papirno, Eds., American Society for Testing and Materials, 1981, pp. 241-253.

3-30. Watson, D. C., "Evaluation of Kevlar (Style 281 Fabric)/F141 Polyester Composite Material for SATCOM Tri-Band Radom," AFWAL-TR-87-124, December 1987.

3.31. DOD/NASA Advanced Composites Design Guide, Vol. 1-Design, July 1983.

## **Chapter 4**

### **Findings/Recommendations**

Several important parameters have been identified for consideration of bolted-joints of composite laminates. The effects of each parameter were elucidated by figures and experimental results. Almost all the experimental data obtained from the literature were for graphite/epoxy and glass/epoxy laminates. Bolted joints data for aramid fibers or organic fibers cannot be found. One additional important point is that almost all the work was geared toward achieving full bearing strength. The efficiency of load-carrying capability of joint-designs has not been studied sufficiently.

For the adhesive study, bulk and bonded forms, cross comparisons between mechanical properties tested by different methods were found to be very limited or deficient. Tensile properties are the easiest to obtain. Dog bone specimens are recommended for evaluating normal properties. For shear properties, confusion exists for moduli values obtained using thick adherend specimens. One group of engineers reported that moduli were linearly proportional to adhesive thickness. This result is highly questionable. More tests and theoretical analysis are needed to confirm this result. The single lap shear test (ASTM D 1002) can be used as a quality control test but should not be used as a tool to determine adhesive properties. The stress distributions for a single lap shear specimen are very complicated. Again, bonded joint specimens with aramid fibers cannot be found in the literature.

**Appendix A-1. Data for single bolted-joints under  
tensile loading.**

1	Material	A	B	C	D	E	F	G	H	I	J	K	L
2	System	Percent of	Stacking	Sequence	Plate	Thickness	Hole	End	W/d	e/d	Joint	Fastener	Fastener
3	Fiber/Resin	plies	Sequence		Width	l (in.)	d (in.)	Distance	Ratio	Ratio	Type	Diameter	Type
4	T300/N5208	25/50/25	[0/45/90/-45]2s		1.504	0.090	0.249	0.758	6.04	3.04	Double	0.249	Ti bolt NAS 464-4
5	T300/N5208	25/50/25	[0/45/90/-45]2s		1.505	0.098	0.250	0.744	6.02	2.98	Double	0.249	Ti bolt NAS 464-4
6	T300/N5208	25/50/25	[0/45/90/-45]2s		1.503	0.091	0.254	1.512	5.92	5.95	Double	0.249	Ti bolt NAS 464-4
7	T300/N5208	25/50/25	[0/45/90/-45]2s		1.503	0.097	0.254	1.514	5.92	5.96	Double	0.249	Ti bolt NAS 464-4
8	T300/N5208	25/50/25	[0/45/90/-45]2s		1.510	0.082	0.250	0.748	6.04	2.99	Double	0.249	Ti bolt NAS 464-4
9	T300/N5208	25/50/25	[0/45/90/-45]2s		1.510	0.091	0.257	0.758	5.88	2.95	Double	0.249	Ti bolt NAS 464-4
10	T300/N5208	25/50/25	[0/45/90/-45]2s		1.507	0.093	0.255	1.512	5.91	5.93	Double	0.249	Ti bolt NAS 464-4
11	T300/N5208	25/50/25	[0/45/90/-45]2s		1.509	0.091	0.254	1.512	5.94	5.95	Double	0.249	Ti bolt NAS 464-4
12	T300/N5208	25/50/25	[0/45/90/-45]2s		1.004	0.087	0.253	0.494	3.97	1.95	Double	0.249	Ti bolt NAS 464-4
13	T300/N5208	25/50/25	[0/45/90/-45]2s		0.994	0.089	0.253	0.495	3.93	1.98	Double	0.249	Ti bolt NAS 464-4
14	T300/N5208	25/50/25	[0/45/90/-45]2s		1.001	0.088	0.249	0.765	4.02	3.07	Double	0.249	Ti bolt NAS 464-4
15	T300/N5208	25/50/25	[0/45/90/-45]2s		0.993	0.089	0.251	0.769	3.96	3.06	Double	0.249	Ti bolt NAS 464-4
16	T300/N5208	25/50/25	[0/45/90/-45]2s		1.003	0.088	0.252	1.005	3.98	3.99	Double	0.249	Ti bolt NAS 464-4
17	T300/N5208	25/50/25	[0/45/90/-45]2s		0.994	0.089	0.251	1.004	3.95	4.00	Double	0.249	Ti bolt NAS 464-4
18	T300/N5208	25/50/25	[0/45/90/-45]2s		1.007	0.082	0.252	0.493	4.00	1.96	Double	0.249	Ti bolt NAS 464-4
19	T300/N5208	25/50/25	[0/45/90/-45]2s		1.005	0.088	0.252	0.496	3.99	1.97	Double	0.249	Ti bolt NAS 464-4
20	T300/N5208	25/50/25	[0/45/90/-45]2s		1.005	0.093	0.249	0.776	4.04	3.12	Double	0.249	Ti bolt NAS 464-4
21	T300/N5208	25/50/25	[0/45/90/-45]2s		1.005	0.089	0.242	0.762	4.15	3.15	Double	0.249	Ti bolt NAS 464-4
22	T300/N5208	25/50/25	[0/45/90/-45]2s		1.006	0.093	0.252	1.006	3.99	3.99	Double	0.249	Ti bolt NAS 464-4
23	T300/N5208	25/50/25	[0/45/90/-45]2s		1.005	0.089	0.251	1.006	4.00	4.01	Double	0.249	Ti bolt NAS 464-4
24	T300/N5208	25/50/25	[0/45/90/-45]2s		0.753	0.092	0.250	0.491	3.01	1.96	Double	0.249	Ti bolt NAS 464-4
25	T300/N5208	25/50/25	[0/45/90/-45]2s		0.758	0.088	0.250	0.490	3.03	1.96	Double	0.249	Ti bolt NAS 464-4
26	T300/N5208	25/50/25	[0/45/90/-45]2s		0.753	0.091	0.246	0.775	3.03	3.15	Double	0.249	Ti bolt NAS 464-4
27	T300/N5208	25/50/25	[0/45/90/-45]2s		0.754	0.091	1.245	0.777	3.08	3.17	Double	0.249	Ti bolt NAS 464-4
28	T300/N5208	25/50/25	[0/45/90/-45]2s		0.753	0.092	0.253	1.006	2.98	3.98	Double	0.249	Ti bolt NAS 464-4
29	T300/N5208	25/50/25	[0/45/90/-45]2s		0.755	0.090	0.252	1.006	3.00	3.99	Double	0.249	Ti bolt NAS 464-4
30	T300/N5208	25/50/25	[0/45/90/-45]2s		0.760	0.089	0.250	0.490	3.04	1.96	Double	0.249	Ti bolt NAS 464-4
31	T300/N5208	25/50/25	[0/45/90/-45]2s		0.762	0.091	0.250	0.490	3.05	1.96	Double	0.249	Ti bolt NAS 464-4
32	T300/N5208	25/50/25	[0/45/90/-45]2s		0.760	0.092	0.253	0.764	3.00	3.10	Double	0.249	Ti bolt NAS 464-4
33	T300/N5208	25/50/25	[0/45/90/-45]2s		0.761	0.091	0.250	0.782	3.04	3.13	Double	0.249	Ti bolt NAS 464-4
34	T300/N5208	25/50/25	[0/45/90/-45]2s		0.760	0.091	0.252	1.005	3.02	3.99	Double	0.249	Ti bolt NAS 464-4
35	T300/N5208	25/50/25	[0/45/90/-45]2s		0.762	0.091	0.252	1.005	3.02	3.98	Double	0.249	Ti bolt NAS 464-4
36	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.504	0.091	0.253	0.756	5.94	2.99	Double	0.249	Ti bolt NAS 464-4
37	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.505	0.091	0.256	0.756	5.88	2.95	Double	0.249	Ti bolt NAS 464-4
38	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.503	0.088	0.254	1.513	5.92	5.96	Double	0.249	Ti bolt NAS 464-4
39	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.503	0.088	0.254	1.514	5.92	5.98	Double	0.249	Ti bolt NAS 464-4
40	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.510	0.088	0.250	0.765	6.04	3.06	Double	0.249	Ti bolt NAS 464-4
41	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.510	0.097	0.253	0.755	5.97	2.98	Double	0.249	Ti bolt NAS 464-4
42	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.507	0.098	0.254	1.512	5.93	5.95	Double	0.249	Ti bolt NAS 464-4
43	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.506	0.088	0.255	1.515	5.92	5.94	Double	0.249	Ti bolt NAS 464-4
44	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.002	0.092	0.252	0.494	3.99	1.97	Double	0.249	Ti bolt NAS 464-4
45	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.007	0.091	0.252	0.494	4.00	1.96	Double	0.249	Ti bolt NAS 464-4
46	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		0.969	0.063	0.249	0.767	4.01	5.03	Double	0.249	Ti bolt NAS 464-4
47	T300/N5208	37 5/37 5/25	[0/45/90/-45]2s		1.002	0.093	0.251	0.775	3.99	5.03	Double	0.249	Ti bolt NAS 464-4

M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Fastener	Test	Moisture	Failing	Bearing	Bearing	Gross	Gross	Shear-out	Gross	Mode	Stiffness	Reference	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	25 RT	Unknown	2090	Unknown	93	Unknown	15.4	15.3	Unknown	Bear	Unknown	Hart-Smith	1-17
2	25 RT	Unknown	2705	Unknown	110	Unknown	18.3	18.5	Unknown	Bear	Unknown	Hart-Smith	1-17
3	25 RT	Unknown	3220	Unknown	142	Unknown	23.5	11.7	Unknown	Bear	Unknown	Hart-Smith	1-17
4	25 RT	Unknown	3275	Unknown	136	Unknown	22.5	11.2	Unknown	Bear	Unknown	Hart-Smith	1-17
5	25 RT	Unknown	2620	Unknown	114	Unknown	18.9	19.1	Unknown	Bear	Unknown	Hart-Smith	1-17
6	25 RT	Unknown	2500	Unknown	110	Unknown	18.2	18.1	Unknown	Bear	Unknown	Hart-Smith	1-17
7	25 RT	Unknown	3125	Unknown	135	Unknown	22.3	11.1	Unknown	Bear	Unknown	Hart-Smith	1-17
8	25 RT	Unknown	2970	Unknown	131	Unknown	21.6	10.8	Unknown	Bear	Unknown	Hart-Smith	1-17
9	25 RT	Unknown	2200	Unknown	102	Unknown	25.2	25.6	Unknown	Tens	Unknown	Hart-Smith	1-17
10	25 RT	Unknown	2225	Unknown	100	Unknown	25.2	25.3	Unknown	Tens	Unknown	Hart-Smith	1-17
11	25 RT	Unknown	2460	Unknown	112	Unknown	27.9	18.3	Unknown	Tens	Unknown	Hart-Smith	1-17
12	25 RT	Unknown	2570	Unknown	115	Unknown	29.1	18.8	Unknown	Tens	Unknown	Hart-Smith	1-17
13	25 RT	Unknown	2575	Unknown	118	Unknown	29.2	14.6	Unknown	Tens	Unknown	Hart-Smith	1-17
14	25 RT	Unknown	2555	Unknown	115	Unknown	28.9	14.3	Unknown	Tens	Unknown	Hart-Smith	1-17
15	25 RT	Unknown	2335	Unknown	102	Unknown	25.2	25.7	Unknown	Tens	Unknown	Hart-Smith	1-17
16	25 RT	Unknown	2150	Unknown	97	Unknown	24.0	24.4	Unknown	Tens	Unknown	Hart-Smith	1-17
17	25 RT	Unknown	2635	Unknown	114	Unknown	28.2	18.3	Unknown	Tens	Unknown	Hart-Smith	1-17
18	25 RT	Unknown	2645	Unknown	118	Unknown	29.6	19.5	Unknown	Tens	Unknown	Hart-Smith	1-17
19	25 RT	Unknown	2605	Unknown	113	Unknown	27.8	13.9	Unknown	Tens	Unknown	Hart-Smith	1-17
20	25 RT	Unknown	2580	Unknown	115	Unknown	28.8	14.4	Unknown	Tens	Unknown	Hart-Smith	1-17
21	25 RT	Unknown	1695	Unknown	74	Unknown	24.5	18.8	Unknown	Tens	Unknown	Hart-Smith	1-17
22	25 RT	Unknown	1940	Unknown	87	Unknown	27.6	13.4	Unknown	Tens	Unknown	Hart-Smith	1-17
23	25 RT	Unknown	1889	Unknown	81	Unknown	28.1	13.6	Unknown	Tens	Unknown	Hart-Smith	1-17
24	25 RT	Unknown	1930	Unknown	85	Unknown	27.1	10.2	Unknown	Tens	Unknown	Hart-Smith	1-17
25	25 RT	Unknown	1880	Unknown	83	Unknown	29.6	11.1	Unknown	Tens	Unknown	Hart-Smith	1-17
26	25 RT	Unknown	2015	Unknown	89	Unknown	28.0	21.7	Unknown	Tens	Unknown	Hart-Smith	1-17
27	25 RT	Unknown	1895	Unknown	85	Unknown	29.8	23.2	Unknown	Tens	Unknown	Hart-Smith	1-17
28	25 RT	Unknown	2065	Unknown	91	Unknown	27.9	13.5	Unknown	Tens	Unknown	Hart-Smith	1-17
29	25 RT	Unknown	1950	Unknown	85	Unknown	27.9	13.6	Unknown	Tens	Unknown	Hart-Smith	1-17
30	25 RT	Unknown	1930	Unknown	85	Unknown	27.9	10.9	Unknown	Tens	Unknown	Hart-Smith	1-17
31	25 RT	Unknown	2000	Unknown	89	Unknown	28.9	11.0	Unknown	Tens	Unknown	Hart-Smith	1-17
32	25 RT	Unknown	2485	Unknown	109	Unknown	29.1	18.1	Unknown	Tens	Unknown	Hart-Smith	1-17
33	25 RT	Unknown	2460	Unknown	109	Unknown	18.0	17.9	Unknown	Bear	Unknown	Hart-Smith	1-17
34	25 RT	Unknown	3250	Unknown	149	Unknown	24.6	12.2	Unknown	Bear	Unknown	Hart-Smith	1-17
35	25 RT	Unknown	3270	Unknown	149	Unknown	24.7	12.3	Unknown	Bear	Unknown	Hart-Smith	1-17
36	25 RT	Unknown	2580	Unknown	108	Unknown	17.4	17.2	Unknown	Bear	Unknown	Hart-Smith	1-17
37	25 RT	Unknown	2180	Unknown	88	Unknown	14.5	14.5	Unknown	Bear	Unknown	Hart-Smith	1-17
38	25 RT	Unknown	3040	Unknown	124	Unknown	20.6	10.3	Unknown	Bear	Unknown	Hart-Smith	1-17
39	25 RT	Unknown	3420	Unknown	139	Unknown	23.1	11.5	Unknown	Bear	Unknown	Hart-Smith	1-17
40	25 RT	Unknown	2115	Unknown	93	Unknown	22.9	23.1	Unknown	Bear	Unknown	Hart-Smith	1-17
41	25 RT	Unknown	2175	Unknown	97	Unknown	23.7	24.2	Unknown	Bear	Unknown	Hart-Smith	1-17
42	25 RT	Unknown	2735	Unknown	118	Unknown	29.4	19.2	Unknown	Bear	Unknown	Hart-Smith	1-17
43	25 RT	Unknown	2905	Unknown	125	Unknown	31.2	20.2	Unknown	Bear	Unknown	Hart-Smith	1-17
44	25 RT	Unknown											
45	25 RT	Unknown											
46	25 RT	Unknown											
47	25 RT	Unknown											

	A	B	C	D	E	F	G	H	I	J	K	L
48	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.000	0.092	0.251	1.004	3.98	4.00	Double	0.249	Ti bolt NAS 484-4
49	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.004	0.092	0.251	1.003	4.00	4.00	Double	0.249	Ti bolt NAS 484-4
50	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.005	0.091	0.253	0.494	3.97	1.95	Double	0.249	Ti bolt NAS 484-4
51	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.004	0.094	0.253	0.494	3.97	1.95	Double	0.249	Ti bolt NAS 484-4
52	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.002	0.093	0.247	0.760	4.06	3.08	Double	0.249	Ti bolt NAS 484-4
53	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.002	0.092	0.249	0.770	4.02	3.09	Double	0.249	Ti bolt NAS 484-4
54	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.003	0.093	0.252	1.007	3.98	4.00	Double	0.249	Ti bolt NAS 484-4
55	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	1.004	0.092	0.253	1.006	3.97	3.98	Double	0.249	Ti bolt NAS 484-4
56	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.762	0.091	0.249	0.491	3.06	1.97	Double	0.249	Ti bolt NAS 484-4
57	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.758	0.094	0.249	0.490	3.04	1.97	Double	0.249	Ti bolt NAS 484-4
58	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.760	0.093	0.249	0.778	3.05	3.12	Double	0.249	Ti bolt NAS 484-4
59	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.757	0.090	0.248	0.761	3.05	3.07	Double	0.249	Ti bolt NAS 484-4
60	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.761	0.092	0.252	1.005	3.02	3.99	Double	0.249	Ti bolt NAS 484-4
61	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.758	0.092	0.254	1.007	2.98	3.96	Double	0.249	Ti bolt NAS 484-4
62	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.758	0.092	0.250	0.491	3.03	1.96	Double	0.249	Ti bolt NAS 484-4
63	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.760	0.092	0.251	0.491	3.03	1.96	Double	0.249	Ti bolt NAS 484-4
64	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.757	0.093	0.247	0.776	3.06	3.14	Double	0.249	Ti bolt NAS 484-4
65	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.757	0.092	0.251	0.781	3.02	3.11	Double	0.249	Ti bolt NAS 484-4
66	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.757	0.092	0.252	1.006	3.00	3.99	Double	0.249	Ti bolt NAS 484-4
67	T300/N5208	37.5/37.5/25	[04.5/900/-45/90/045/-45/90/-45/90/045/0]	0.759	0.093	0.253	1.007	3.00	3.98	Double	0.249	Ti bolt NAS 484-4
68	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.493	0.0911	0.251	0.749	5.94	2.98	Double	0.249	Ti bolt NAS 484-4
69	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.491	0.0916	0.254	1.513	5.87	5.96	Double	0.249	Ti bolt NAS 484-4
70	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.483	0.0872	0.255	1.514	5.82	5.95	Double	0.249	Ti bolt NAS 484-4
71	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.488	0.0866	0.255	0.752	5.84	2.95	Double	0.249	Ti bolt NAS 484-4
72	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.494	0.092	0.250	0.756	5.97	3.02	Double	0.249	Ti bolt NAS 484-4
73	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.476	0.0887	0.255	1.514	5.79	5.94	Double	0.249	Ti bolt NAS 484-4
74	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.499	0.192	0.254	1.512	5.91	5.96	Double	0.249	Ti bolt NAS 484-4
75	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.535	0.0898	0.254	0.755	6.05	2.98	Double	0.249	Ti bolt NAS 484-4
76	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.003	0.0923	0.252	0.495	3.98	1.96	Double	0.249	Ti bolt NAS 484-4
77	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.994	0.0928	0.250	0.765	3.98	3.06	Double	0.249	Ti bolt NAS 484-4
78	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.998	0.0926	0.252	1.005	3.96	3.95	Double	0.249	Ti bolt NAS 484-4
79	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.001	0.0916	0.252	1.006	3.97	3.99	Double	0.249	Ti bolt NAS 484-4
80	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.996	0.0908	0.249	0.770	4.00	3.09	Double	0.249	Ti bolt NAS 484-4
81	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.005	0.0925	0.253	0.495	3.97	1.95	Double	0.249	Ti bolt NAS 484-4
82	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.008	0.0938	0.252	0.492	3.99	1.95	Double	0.249	Ti bolt NAS 484-4
83	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.004	0.0937	0.251	0.765	4.00	3.05	Double	0.249	Ti bolt NAS 484-4
84	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.005	0.0938	0.251	1.008	4.00	4.02	Double	0.249	Ti bolt NAS 484-4
85	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.002	0.0921	0.251	1.007	4.00	4.02	Double	0.249	Ti bolt NAS 484-4
86	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.000	0.0929	0.251	0.773	3.98	3.08	Double	0.249	Ti bolt NAS 484-4
87	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	1.003	0.0913	0.252	0.495	3.98	1.97	Double	0.249	Ti bolt NAS 484-4
88	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.761	0.0915	0.251	0.498	3.04	1.95	Double	0.249	Ti bolt NAS 484-4
89	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.763	0.0929	0.246	1.007	3.11	3.16	Double	0.249	Ti bolt NAS 484-4
90	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.762	0.0922	0.253	1.007	3.02	3.99	Double	0.249	Ti bolt NAS 484-4
91	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.757	0.0925	0.253	1.007	2.99	3.98	Double	0.249	Ti bolt NAS 484-4
92	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.754	0.0916	0.248	0.778	3.04	3.14	Double	0.249	Ti bolt NAS 484-4
93	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.760	0.0943	0.251	0.489	3.03	1.95	Double	0.249	Ti bolt NAS 484-4
94	T300/N5208	37.5/50/12.5	[0.4/5/0/-45/90/45/0/-45/5]	0.752	0.0939	0.251	0.492	3.00	1.96	Double	0.249	Ti bolt NAS 484-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
48	25 RT	Unknown	Unknown	2775	Unknown	121	Unknown	30.2	15.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
49	25 RT	Unknown	Unknown	3000	Unknown	131	Unknown	32.5	16.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
50	25 RT	Unknown	Unknown	2200	Unknown	97	Unknown	24.1	24.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
51	25 RT	Unknown	Unknown	2330	Unknown	98	Unknown	24.7	25.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
52	25 RT	Unknown	Unknown	2770	Unknown	119	Unknown	29.7	19.6	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
53	25 RT	Unknown	Unknown	2760	Unknown	121	Unknown	29.9	19.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
54	25 RT	Unknown	Unknown	2810	Unknown	121	Unknown	30.1	15.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
55	25 RT	Unknown	Unknown	2800	Unknown	122	Unknown	30.3	15.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
56	25 RT	Unknown	Unknown	2210	Unknown	98	Unknown	31.9	24.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
57	25 RT	Unknown	Unknown	2110	Unknown	90	Unknown	29.6	22.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
58	25 RT	Unknown	Unknown	2200	Unknown	95	Unknown	31.1	15.2	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
59	25 RT	Unknown	Unknown	2140	Unknown	95	Unknown	31.4	15.8	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
60	25 RT	Unknown	Unknown	2165	Unknown	100	Unknown	30.9	11.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
61	25 RT	Unknown	Unknown	2140	Unknown	94	Unknown	30.7	11.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
62	25 RT	Unknown	Unknown	2025	Unknown	89	Unknown	29.0	22.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
63	25 RT	Unknown	Unknown	2050	Unknown	89	Unknown	29.3	22.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
64	25 RT	Unknown	Unknown	2150	Unknown	93	Unknown	30.5	14.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
65	25 RT	Unknown	Unknown	2265	Unknown	98	Unknown	32.2	15.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
66	25 RT	Unknown	Unknown	2095	Unknown	91	Unknown	30.1	11.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
67	25 RT	Unknown	Unknown	2225	Unknown	96	Unknown	31.5	11.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
68	25 RT	Unknown	Unknown	2620	Unknown	115	Unknown	19.3	19.2	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
69	25 RT	Unknown	Unknown	3140	Unknown	137	Unknown	23.0	11.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
70	25 RT	Unknown	Unknown	3000	Unknown	137	Unknown	23.2	11.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
71	25 RT	Unknown	Unknown	2825	Unknown	131	Unknown	21.9	21.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
72	25 RT	Unknown	Unknown	2820	Unknown	123	Unknown	20.5	20.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
73	25 RT	Unknown	Unknown	2965	Unknown	134	Unknown	22.6	11.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
74	25 RT	Unknown	Unknown	3185	Unknown	139	Unknown	11.1	5.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
75	25 RT	Unknown	Unknown	2565	Unknown	114	Unknown	18.6	18.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
76	25 RT	Unknown	Unknown	2350	Unknown	102	Unknown	25.4	25.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
77	25 RT	Unknown	Unknown	2695	Unknown	116	Unknown	29.2	19.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
78	25 RT	Unknown	Unknown	2950	Unknown	128	Unknown	31.9	15.8	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
79	25 RT	Unknown	Unknown	2920	Unknown	128	Unknown	31.8	15.8	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
80	25 RT	Unknown	Unknown	3015	Unknown	133	Unknown	33.3	21.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
81	25 RT	Unknown	Unknown	2415	Unknown	105	Unknown	28.0	26.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
82	25 RT	Unknown	Unknown	2430	Unknown	104	Unknown	25.8	26.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
83	25 RT	Unknown	Unknown	2565	Unknown	110	Unknown	27.3	17.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
84	25 RT	Unknown	Unknown	2970	Unknown	127	Unknown	31.5	15.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
85	25 RT	Unknown	Unknown	3340	Unknown	145	Unknown	36.2	18.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
86	25 RT	Unknown	Unknown	2715	Unknown	117	Unknown	29.2	18.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
87	25 RT	Unknown	Unknown	2330	Unknown	102	Unknown	25.4	25.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
88	25 RT	Unknown	Unknown	2075	Unknown	91	Unknown	29.8	23.2	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
89	25 RT	Unknown	Unknown	2350	Unknown	101	Unknown	33.2	16.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
90	25 RT	Unknown	Unknown	2400	Unknown	104	Unknown	34.2	12.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
91	25 RT	Unknown	Unknown	2340	Unknown	101	Unknown	33.2	12.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
92	25 RT	Unknown	Unknown	2605	Unknown	114	Unknown	37.7	18.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
93	25 RT	Unknown	Unknown	2205	Unknown	94	Unknown	30.8	23.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
94	25 RT	Unknown	Unknown	2230	Unknown	95	Unknown	31.6	24.1	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep

	A	B	C	D	E	F	G	H	I	J	K	L
95	T300/N5208	37.5/50/12.5	[0/45/90/-45/90/45/0/-45]s	0.759	0.0923	0.254	0.778	2.99	3.06	Double	0.249	Ti bolt NAS 464-4
96	T300/N5208	37.5/50/12.5	[0/45/90/-45/90/45/0/-45]s	0.756	0.0931	0.253	1.007	2.99	3.98	Double	0.249	Ti bolt NAS 464-4
97	T300/N5208	37.5/50/12.5	[0/45/90/-45/90/45/0/-45]s	0.759	0.0916	0.253	1.007	3.01	3.99	Double	0.249	Ti bolt NAS 464-4
98	T300/N5208	37.5/50/12.5	[0/45/90/-45/90/45/0/-45]s	0.758	0.0921	0.252	0.778	3.01	3.09	Double	0.249	Ti bolt NAS 464-4
99	T300/N5208	37.5/50/12.5	[0/45/90/-45/90/45/0/-45]s	0.759	0.0911	0.250	0.492	3.04	1.97	Double	0.249	Ti bolt NAS 464-4
100	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.501	0.891	0.251	0.720	5.98	2.87	Double	0.249	Ti bolt NAS 464-4
101	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.497	0.089	0.254	1.510	5.89	5.94	Double	0.249	Ti bolt NAS 464-4
102	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.486	0.0904	0.253	1.509	5.87	5.96	Double	0.249	Ti bolt NAS 464-4
103	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.485	0.0894	0.256	0.757	5.80	2.96	Double	0.249	Ti bolt NAS 464-4
104	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.497	0.087	0.252	0.710	5.94	2.82	Double	0.249	Ti bolt NAS 464-4
105	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.483	0.09	0.253	1.499	5.86	5.92	Double	0.249	Ti bolt NAS 464-4
106	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.497	0.0895	0.253	1.503	5.92	5.94	Double	0.249	Ti bolt NAS 464-4
107	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.480	0.089	0.256	0.756	5.78	2.95	Double	0.249	Ti bolt NAS 464-4
108	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.005	0.0908	0.253	0.493	3.97	1.95	Double	0.249	Ti bolt NAS 464-4
109	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.001	0.0897	0.250	0.772	4.00	3.09	Double	0.249	Ti bolt NAS 464-4
110	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.003	0.0903	0.252	1.006	3.98	3.99	Double	0.249	Ti bolt NAS 464-4
111	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.001	0.0892	0.252	1.007	3.97	4.00	Double	0.249	Ti bolt NAS 464-4
112	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.001	0.0898	0.250	0.773	4.00	3.09	Double	0.249	Ti bolt NAS 464-4
113	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.001	0.0886	0.253	0.494	3.96	1.95	Double	0.249	Ti bolt NAS 464-4
114	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.008	0.0899	0.252	0.494	4.03	1.98	Double	0.249	Ti bolt NAS 464-4
115	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.005	0.0904	0.250	0.766	4.00	3.05	Double	0.249	Ti bolt NAS 464-4
116	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.006	0.0902	0.251	1.006	3.99	3.99	Double	0.249	Ti bolt NAS 464-4
117	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.001	0.089	0.252	1.007	4.05	4.08	Double	0.249	Ti bolt NAS 464-4
118	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.999	0.0886	0.247	0.769	3.95	3.04	Double	0.249	Ti bolt NAS 464-4
119	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	1.003	0.0893	0.253	0.494	4.00	1.97	Double	0.249	Ti bolt NAS 464-4
120	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.755	0.0892	0.251	0.491	3.02	1.96	Double	0.249	Ti bolt NAS 464-4
121	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.755	0.0897	0.250	0.779	2.98	3.08	Double	0.249	Ti bolt NAS 464-4
122	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.755	0.0895	0.253	1.007	2.97	3.96	Double	0.249	Ti bolt NAS 464-4
123	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.762	0.0897	0.254	1.006	3.06	4.04	Double	0.249	Ti bolt NAS 464-4
124	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.759	0.0893	0.249	0.787	3.02	3.14	Double	0.249	Ti bolt NAS 464-4
125	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.764	0.0901	0.251	0.490	3.05	1.96	Double	0.249	Ti bolt NAS 464-4
126	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.763	0.0917	0.251	0.490	3.05	1.96	Double	0.249	Ti bolt NAS 464-4
127	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.760	0.0901	0.250	0.773	3.00	3.08	Double	0.249	Ti bolt NAS 464-4
128	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.761	0.0909	0.253	1.009	2.98	3.96	Double	0.249	Ti bolt NAS 464-4
129	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.766	0.0911	0.255	1.009	3.06	4.04	Double	0.249	Ti bolt NAS 464-4
130	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.766	0.091	0.250	0.787	3.05	3.14	Double	0.249	Ti bolt NAS 464-4
131	GI/T300/N5208	25/50/25	[0/45/90/-45]2s	0.765	0.0911	0.251	0.490	3.05	1.95	Double	0.249	Ti bolt NAS 464-4
132	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.490	0.088	0.251	0.728	5.94	2.90	Double	0.249	Ti bolt NAS 464-4
133	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.493	0.0876	0.254	1.507	5.88	5.93	Double	0.249	Ti bolt NAS 464-4
134	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.500	0.0857	0.255	1.508	5.88	5.91	Double	0.249	Ti bolt NAS 464-4
135	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.508	0.0858	0.256	0.730	5.89	2.85	Double	0.249	Ti bolt NAS 464-4
136	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.497	0.0861	0.251	0.734	5.96	2.92	Double	0.249	Ti bolt NAS 464-4
137	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.494	0.0867	0.255	1.506	5.86	5.91	Double	0.249	Ti bolt NAS 464-4
138	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.501	0.086	0.253	1.505	5.93	5.95	Double	0.249	Ti bolt NAS 464-4
139	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	1.509	0.0862	0.256	0.750	5.89	2.93	Double	0.249	Ti bolt NAS 464-4
140	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	0.990	0.0882	0.253	0.493	3.91	1.95	Double	0.249	Ti bolt NAS 464-4
141	GI/T300/N5208	37.5/37.5/25	[0/45/90/-45/90/45/-45/90/45/0]s	0.992	0.0889	0.252	0.769	3.90	3.05	Double	0.249	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
95	25 RT		Unknown	2530	Unknown	110	Unknown	36.1	17.6	Unknown	Tens	Unknown	Hart-Smith	1-17	Gr/Ep
96	25 RT		Unknown	2370	Unknown	102	Unknown	33.7	12.6	Unknown	Tens	Unknown	Hart-Smith	1-17	Gr/Ep
97	25 RT		Unknown	2600	Unknown	114	Unknown	37.4	14.1	Unknown	Tens	Unknown	Hart-Smith	1-17	Gr/Ep
98	25 RT		Unknown	2470	Unknown	108	Unknown	35.4	17.2	Unknown	Tens	Unknown	Hart-Smith	1-17	Gr/Ep
99	25 RT		Unknown	2345	Unknown	103	Unknown	33.9	26.2	Unknown	Tens	Unknown	Hart-Smith	1-17	Gr/Ep
100	25 RT		Unknown	2645	Unknown	119	Unknown	2.0	2.1	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
101	25 RT		Unknown	3155	Unknown	142	Unknown	23.7	11.7	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
102	25 RT		Unknown	3040	Unknown	135	Unknown	22.6	11.1	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
103	25 RT		Unknown	2680	Unknown	120	Unknown	20.2	19.8	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
104	25 RT		Unknown	2330	Unknown	107	Unknown	17.9	18.9	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
105	25 RT		Unknown	3250	Unknown	145	Unknown	24.4	12.0	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
106	25 RT		Unknown	3035	Unknown	136	Unknown	22.7	11.3	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
107	25 RT		Unknown	2140	Unknown	96	Unknown	16.2	15.9	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
108	25 RT		Unknown	2410	Unknown	107	Unknown	26.4	26.9	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
109	25 RT		Unknown	2830	Unknown	127	Unknown	31.5	20.4	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
110	25 RT		Unknown	2780	Unknown	123	Unknown	30.7	15.3	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
111	25 RT		Unknown	2695	Unknown	121	Unknown	30.2	15.0	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
112	25 RT		Unknown	2710	Unknown	121	Unknown	30.1	19.5	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
113	25 RT		Unknown	2230	Unknown	101	Unknown	25.1	25.5	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
114	25 RT		Unknown	2410	Unknown	108	Unknown	26.6	27.1	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
115	25 RT		Unknown	2975	Unknown	132	Unknown	32.7	21.5	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
116	25 RT		Unknown	2725	Unknown	121	Unknown	30.0	15.0	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
117	25 RT		Unknown	2700	Unknown	122	Unknown	30.3	15.1	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
118	25 RT		Unknown	2690	Unknown	122	Unknown	30.4	19.7	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
119	25 RT		Unknown	2310	Unknown	104	Unknown	25.8	26.2	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
120	25 RT		Unknown	2265	Unknown	102	Unknown	33.6	25.9	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
121	25 RT		Unknown	2355	Unknown	105	Unknown	34.8	16.9	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
122	25 RT		Unknown	2435	Unknown	109	Unknown	36.0	13.5	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
123	25 RT		Unknown	2300	Unknown	103	Unknown	33.6	12.7	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
124	25 RT		Unknown	2360	Unknown	106	Unknown	34.8	16.8	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
125	25 RT		Unknown	2280	Unknown	102	Unknown	33.1	25.7	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
126	25 RT		Unknown	2250	Unknown	99	Unknown	32.2	25.0	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
127	25 RT		Unknown	2365	Unknown	105	Unknown	34.5	17.0	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
128	25 RT		Unknown	2485	Unknown	110	Unknown	35.9	13.5	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
129	25 RT		Unknown	2505	Unknown	110	Unknown	35.9	13.6	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
130	25 RT		Unknown	2345	Unknown	103	Unknown	33.6	16.4	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
131	25 RT		Unknown	1955	Unknown	86	Unknown	28.1	21.9	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
132	25 RT		Unknown	2380	Unknown	111	Unknown	18.6	19.0	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
133	25 RT		Unknown	2865	Unknown	131	Unknown	21.9	10.9	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
134	25 RT		Unknown	2475	Unknown	116	Unknown	19.3	9.6	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
135	25 RT		Unknown	2315	Unknown	108	Unknown	17.9	18.5	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
136	25 RT		Unknown	2475	Unknown	115	Unknown	19.2	19.6	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
137	25 RT		Unknown	2630	Unknown	122	Unknown	20.3	10.1	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
138	25 RT		Unknown	2775	Unknown	129	Unknown	21.5	10.7	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
139	25 RT		Unknown	2495	Unknown	116	Unknown	19.2	19.3	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
140	25 RT		Unknown	2120	Unknown	97	Unknown	24.3	24.4	Unknown	Sher	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply
141	25 RT		Unknown	2650	Unknown	119	Unknown	30.4	19.4	Unknown	Bear	Unknown	Hart-Smith	1-17	Hybrid, S-1004 Gl for O-Ply

## Single J-Tension

A	B	C	D	E	F	G	H	I	J	K	L
142	GI/T300/N5208	37.5/37.5/25	0.986	0.0886	0.253	1.010	3.90	3.99	Double	0.249	Ti bolt NAS 464-4
143	GI/T300/N5208	37.5/37.5/25	1.005	0.0893	0.252	1.007	3.99	4.00	Double	0.249	Ti bolt NAS 464-4
144	GI/T300/N5208	37.5/37.5/25	1.002	0.0898	0.253	0.768	3.98	3.04	Double	0.249	Ti bolt NAS 464-4
145	GI/T300/N5208	37.5/37.5/25	1.009	0.0888	0.253	0.496	3.99	1.98	Double	0.249	Ti bolt NAS 464-4
146	GI/T300/N5208	37.5/37.5/25	1.000	0.0816	0.253	0.495	3.95	1.96	Double	0.249	Ti bolt NAS 464-4
147	GI/T300/N5208	37.5/37.5/25	0.999	0.0887	0.252	0.767	3.98	3.04	Double	0.249	Ti bolt NAS 464-4
148	GI/T300/N5208	37.5/37.5/25	0.999	0.0882	0.253	1.008	3.97	3.98	Double	0.249	Ti bolt NAS 464-4
149	GI/T300/N5208	37.5/37.5/25	1.005	0.0888	0.253	1.008	3.97	3.98	Double	0.249	Ti bolt NAS 464-4
150	GI/T300/N5208	37.5/37.5/25	1.005	0.0889	0.249	0.771	4.04	3.10	Double	0.249	Ti bolt NAS 464-4
151	GI/T300/N5208	37.5/37.5/25	1.005	0.0887	0.253	0.493	3.97	1.95	Double	0.249	Ti bolt NAS 464-4
152	GI/T300/N5208	37.5/37.5/25	0.759	0.0878	0.252	0.492	3.01	1.95	Double	0.249	Ti bolt NAS 464-4
153	GI/T300/N5208	37.5/37.5/25	0.756	0.0882	0.249	0.766	3.04	3.16	Double	0.249	Ti bolt NAS 464-4
154	GI/T300/N5208	37.5/37.5/25	0.757	0.088	0.254	1.007	2.98	3.98	Double	0.249	Ti bolt NAS 464-4
155	GI/T300/N5208	37.5/37.5/25	0.758	0.0895	0.254	1.009	2.99	3.97	Double	0.249	Ti bolt NAS 464-4
156	GI/T300/N5208	37.5/37.5/25	0.758	0.0893	0.249	0.776	3.03	3.12	Double	0.249	Ti bolt NAS 464-4
157	GI/T300/N5208	37.5/37.5/25	0.761	0.0898	0.251	0.491	3.03	1.98	Double	0.249	Ti bolt NAS 464-4
158	GI/T300/N5208	37.5/37.5/25	0.754	0.0885	0.252	0.493	2.99	1.98	Double	0.249	Ti bolt NAS 464-4
159	GI/T300/N5208	37.5/37.5/25	0.752	0.086	0.247	0.779	3.04	3.15	Double	0.249	Ti bolt NAS 464-4
160	GI/T300/N5208	37.5/37.5/25	0.753	0.0863	0.253	1.004	2.98	3.97	Double	0.249	Ti bolt NAS 464-4
161	GI/T300/N5208	37.5/37.5/25	0.758	0.0871	0.253	1.006	3.00	3.98	Double	0.249	Ti bolt NAS 464-4
162	GI/T300/N5208	37.5/37.5/25	0.757	0.0878	0.250	0.773	3.03	3.08	Double	0.249	Ti bolt NAS 464-4
163	GI/T300/N5208	37.5/37.5/25	0.759	0.0864	0.251	0.491	3.02	1.98	Double	0.249	Ti bolt NAS 464-4
164	GI/T300/N5208	37.5/50/12.5	1.498	0.0873	0.255	0.757	5.86	2.97	Double	0.249	Ti bolt NAS 464-4
165	GI/T300/N5208	37.5/50/12.5	1.498	0.0871	0.253	1.511	5.92	5.97	Double	0.249	Ti bolt NAS 464-4
166	GI/T300/N5208	37.5/50/12.5	1.495	0.0873	0.254	1.510	5.89	5.95	Double	0.249	Ti bolt NAS 464-4
167	GI/T300/N5208	37.5/50/12.5	1.498	0.0855	0.251	0.755	5.97	3.01	Double	0.249	Ti bolt NAS 464-4
168	GI/T300/N5208	37.5/50/12.5	1.496	0.0875	0.255	0.747	5.86	2.93	Double	0.249	Ti bolt NAS 464-4
169	GI/T300/N5208	37.5/50/12.5	1.495	0.0872	0.255	1.510	5.86	5.92	Double	0.249	Ti bolt NAS 464-4
170	GI/T300/N5208	37.5/50/12.5	1.500	0.0847	0.255	1.511	5.88	5.93	Double	0.249	Ti bolt NAS 464-4
171	GI/T300/N5208	37.5/50/12.5	1.498	0.0854	0.251	0.742	5.97	2.96	Double	0.249	Ti bolt NAS 464-4
172	GI/T300/N5208	37.5/50/12.5	1.010	0.0875	0.252	0.492	4.01	1.95	Double	0.249	Ti bolt NAS 464-4
173	GI/T300/N5208	37.5/50/12.5	1.003	0.082	0.249	0.744	4.04	3.00	Double	0.249	Ti bolt NAS 464-4
174	GI/T300/N5208	37.5/50/12.5	1.007	0.0848	0.253	1.009	3.98	3.98	Double	0.249	Ti bolt NAS 464-4
175	GI/T300/N5208	37.5/50/12.5	0.995	0.0861	0.254	1.009	3.92	3.97	Double	0.249	Ti bolt NAS 464-4
176	GI/T300/N5208	37.5/50/12.5	0.994	0.0875	0.252	0.764	3.94	3.03	Double	0.249	Ti bolt NAS 464-4
177	GI/T300/N5208	37.5/50/12.5	0.996	0.0847	0.253	0.493	3.94	1.95	Double	0.249	Ti bolt NAS 464-4
178	GI/T300/N5208	37.5/50/12.5	1.008	0.085	0.254	0.492	3.96	1.94	Double	0.249	Ti bolt NAS 464-4
179	GI/T300/N5208	37.5/50/12.5	1.002	0.0865	0.253	0.769	3.98	3.04	Double	0.249	Ti bolt NAS 464-4
180	GI/T300/N5208	37.5/50/12.5	1.004	0.0858	0.252	1.007	3.98	4.00	Double	0.249	Ti bolt NAS 464-4
181	GI/T300/N5208	37.5/50/12.5	0.998	0.086	0.252	1.010	3.98	4.01	Double	0.249	Ti bolt NAS 464-4
182	GI/T300/N5208	37.5/50/12.5	0.996	0.086	0.251	0.768	3.97	3.06	Double	0.249	Ti bolt NAS 464-4
183	GI/T300/N5208	37.5/50/12.5	0.999	0.0859	0.253	0.495	3.95	1.98	Double	0.249	Ti bolt NAS 464-4
184	GI/T300/N5208	37.5/50/12.5	0.759	0.0863	0.252	0.492	3.01	1.95	Double	0.249	Ti bolt NAS 464-4
185	GI/T300/N5208	37.5/50/12.5	0.758	0.0862	0.245	0.771	3.09	3.15	Double	0.249	Ti bolt NAS 464-4
186	GI/T300/N5208	37.5/50/12.5	0.760	0.0863	0.254	1.007	2.99	3.98	Double	0.249	Ti bolt NAS 464-4
187	GI/T300/N5208	37.5/50/12.5	0.760	0.0865	0.254	1.007	2.99	3.96	Double	0.249	Ti bolt NAS 464-4
188	GI/T300/N5208	37.5/50/12.5	0.759	0.0852	0.249	0.771	3.05	3.10	Double	0.249	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
142	25 RT	Unknown	Unknown	2900	Unknown	131	Unknown	33.2	16.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
143	25 RT	Unknown	Unknown	2715	Unknown	121	Unknown	30.3	15.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
144	25 RT	Unknown	Unknown	2535	Unknown	113	Unknown	28.2	18.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
145	25 RT	Unknown	Unknown	2110	Unknown	95	Unknown	23.5	24.0	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
146	25 RT	Unknown	Unknown	2230	Unknown	109	Unknown	27.3	27.6	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
147	25 RT	Unknown	Unknown	2850	Unknown	129	Unknown	32.2	20.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
148	25 RT	Unknown	Unknown	2605	Unknown	123	Unknown	30.6	15.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
149	25 RT	Unknown	Unknown	2820	Unknown	127	Unknown	31.6	15.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
150	25 RT	Unknown	Unknown	2520	Unknown	113	Unknown	28.2	18.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
151	25 RT	Unknown	Unknown	2280	Unknown	103	Unknown	25.6	26.1	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
152	25 RT	Unknown	Unknown	2040	Unknown	93	Unknown	30.6	23.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
153	25 RT	Unknown	Unknown	2435	Unknown	111	Unknown	36.5	17.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
154	25 RT	Unknown	Unknown	2635	Unknown	120	Unknown	39.6	14.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
155	25 RT	Unknown	Unknown	2665	Unknown	119	Unknown	39.2	14.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
156	25 RT	Unknown	Unknown	2480	Unknown	111	Unknown	36.6	17.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
157	25 RT	Unknown	Unknown	2005	Unknown	89	Unknown	29.3	22.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
158	25 RT	Unknown	Unknown	2215	Unknown	103	Unknown	34.0	26.0	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
159	25 RT	Unknown	Unknown	2540	Unknown	118	Unknown	39.3	19.0	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
160	25 RT	Unknown	Unknown	2535	Unknown	118	Unknown	39.0	14.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
161	25 RT	Unknown	Unknown	2570	Unknown	118	Unknown	38.9	14.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
162	25 RT	Unknown	Unknown	2635	Unknown	120	Unknown	39.6	19.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
163	25 RT	Unknown	Unknown	2105	Unknown	98	Unknown	32.1	24.8	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
164	25 RT	Unknown	Unknown	2425	Unknown	111	Unknown	18.6	18.3	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
165	25 RT	Unknown	Unknown	2730	Unknown	126	Unknown	20.9	10.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
166	25 RT	Unknown	Unknown	3005	Unknown	138	Unknown	23.0	11.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
167	25 RT	Unknown	Unknown	2485	Unknown	116	Unknown	19.4	19.2	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
168	25 RT	Unknown	Unknown	2225	Unknown	102	Unknown	17.0	17.0	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
169	25 RT	Unknown	Unknown	3025	Unknown	139	Unknown	23.2	11.5	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
170	25 RT	Unknown	Unknown	3075	Unknown	146	Unknown	24.2	12.0	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
171	25 RT	Unknown	Unknown	2515	Unknown	118	Unknown	19.7	19.8	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
172	25 RT	Unknown	Unknown	2350	Unknown	108	Unknown	26.6	27.3	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
173	25 RT	Unknown	Unknown	2475	Unknown	121	Unknown	30.1	20.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
174	25 RT	Unknown	Unknown	2495	Unknown	118	Unknown	29.2	14.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
175	25 RT	Unknown	Unknown	2800	Unknown	130	Unknown	32.7	16.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
176	25 RT	Unknown	Unknown	2820	Unknown	129	Unknown	32.4	21.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
177	25 RT	Unknown	Unknown	2285	Unknown	107	Unknown	26.8	27.1	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
178	25 RT	Unknown	Unknown	2280	Unknown	108	Unknown	26.7	27.3	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
179	25 RT	Unknown	Unknown	2555	Unknown	118	Unknown	29.5	19.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
180	25 RT	Unknown	Unknown	2710	Unknown	127	Unknown	31.5	15.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
181	25 RT	Unknown	Unknown	2705	Unknown	126	Unknown	31.5	15.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
182	25 RT	Unknown	Unknown	2600	Unknown	121	Unknown	30.4	19.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
183	25 RT	Unknown	Unknown	2310	Unknown	108	Unknown	26.9	27.2	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
184	25 RT	Unknown	Unknown	2355	Unknown	109	Unknown	36.0	27.7	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
185	25 RT	Unknown	Unknown	2600	Unknown	121	Unknown	39.8	19.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
186	25 RT	Unknown	Unknown	2375	Unknown	110	Unknown	36.2	13.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
187	25 RT	Unknown	Unknown	2590	Unknown	120	Unknown	39.4	14.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply
188	25 RT	Unknown	Unknown	2535	Unknown	119	Unknown	39.2	19.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 Gl for O-Ply

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
189	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.762	0.0878	0.251	0.491	3.04	1.96	Double	0.249	Ti bolt NAS 464-4
190	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.759	0.0835	0.251	0.491	3.02	1.96	Double	0.249	Ti bolt NAS 464-4
191	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.756	0.0859	0.250	0.779	3.02	3.12	Double	0.249	Ti bolt NAS 464-4
192	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.758	0.0847	0.254	1.007	2.98	3.96	Double	0.249	Ti bolt NAS 464-4
193	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.754	0.0866	0.255	1.007	2.96	3.95	Double	0.249	Ti bolt NAS 464-4
194	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.753	0.0864	0.249	0.780	3.02	3.13	Double	0.249	Ti bolt NAS 464-4
195	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	0.754	0.0867	0.251	0.490	3.00	1.95	Double	0.249	Ti bolt NAS 464-4
196	T300/N5208	25/50/25	0/45/90/-45/2s	2.502	0.0903	0.250	0.504	10.01	2.02	Double	0.249	Ti bolt NAS 464-4
197	T300/N5208	25/50/25	0/45/90/-45/2s	2.495	0.0922	0.250	1.488	9.98	5.95	Double	0.249	Ti bolt NAS 464-4
198	T300/N5208	25/50/25	0/45/90/-45/2s	2.501	0.0898	0.251	2.003	9.99	7.98	Double	0.249	Ti bolt NAS 464-4
199	T300/N5208	25/50/25	0/45/90/-45/2s	2.508	0.0895	0.251	1.009	9.99	4.02	Double	0.249	Ti bolt NAS 464-4
200	T300/N5208	25/50/25	0/45/90/-45/2s	2.504	0.0918	0.250	0.504	10.02	2.02	Double	0.249	Ti bolt NAS 464-4
201	T300/N5208	25/50/25	0/45/90/-45/2s	2.506	0.0918	0.251	1.487	9.98	5.92	Double	0.249	Ti bolt NAS 464-4
202	T300/N5208	25/50/25	0/45/90/-45/2s	2.518	0.0907	0.251	2.005	10.03	7.99	Double	0.249	Ti bolt NAS 464-4
203	T300/N5208	25/50/25	0/45/90/-45/2s	2.501	0.0899	0.251	1.019	9.96	4.06	Double	0.249	Ti bolt NAS 464-4
204	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.504	0.0917	0.250	0.503	10.02	2.01	Double	0.249	Ti bolt NAS 464-4
205	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.498	0.0922	0.250	1.489	9.99	5.96	Double	0.249	Ti bolt NAS 464-4
206	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.498	0.0926	0.251	2.003	9.96	7.98	Double	0.249	Ti bolt NAS 464-4
207	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.508	0.0912	0.251	1.022	9.99	4.07	Double	0.249	Ti bolt NAS 464-4
208	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.506	0.0932	0.251	0.504	9.99	2.01	Double	0.249	Ti bolt NAS 464-4
209	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.508	0.0912	0.250	1.492	10.02	5.97	Double	0.249	Ti bolt NAS 464-4
210	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.507	0.0927	0.251	2.005	9.99	7.99	Double	0.249	Ti bolt NAS 464-4
211	T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.506	0.0936	0.251	0.993	9.98	3.96	Double	0.249	Ti bolt NAS 464-4
212	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.510	0.0914	0.249	0.503	10.08	2.02	Double	0.249	Ti bolt NAS 464-4
213	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.513	0.0918	0.249	1.486	10.07	5.97	Double	0.249	Ti bolt NAS 464-4
214	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.517	0.0903	0.249	2.008	10.09	8.06	Double	0.249	Ti bolt NAS 464-4
215	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.517	0.08	0.250	1.005	10.07	4.02	Double	0.249	Ti bolt NAS 464-4
216	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.504	0.0881	0.251	0.505	9.98	2.01	Double	0.249	Ti bolt NAS 464-4
217	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.508	0.0899	0.250	1.487	10.02	5.95	Double	0.249	Ti bolt NAS 464-4
218	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.513	0.0902	0.251	2.004	10.01	7.98	Double	0.249	Ti bolt NAS 464-4
219	T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.517	0.09	0.250	1.006	10.07	4.02	Double	0.249	Ti bolt NAS 464-4
220	GI/T300/N5208	25/50/25	0/45/90/-45/2s	2.507	0.0911	0.249	0.504	10.07	2.02	Double	0.249	Ti bolt NAS 464-4
221	GI/T300/N5208	25/50/25	0/45/90/-45/2s	2.504	0.0915	0.250	1.491	10.02	5.96	Double	0.249	Ti bolt NAS 464-4
222	GI/T300/N5208	25/50/25	0/45/90/-45/2s	2.505	0.0911	0.248	2.000	10.10	8.06	Double	0.249	Ti bolt NAS 464-4
223	GI/T300/N5208	25/50/25	0/45/90/-45/2s	2.507	0.091	0.249	0.993	10.07	3.98	Double	0.249	Ti bolt NAS 464-4
224	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.507	0.0912	0.249	0.504	10.07	2.02	Double	0.249	Ti bolt NAS 464-4
225	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.507	0.0872	0.250	1.487	10.03	5.95	Double	0.249	Ti bolt NAS 464-4
226	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.506	0.086	0.249	2.002	10.06	8.04	Double	0.249	Ti bolt NAS 464-4
227	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.509	0.0875	0.248	0.998	10.12	4.02	Double	0.249	Ti bolt NAS 464-4
228	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.506	0.087	0.249	0.505	10.08	2.03	Double	0.249	Ti bolt NAS 464-4
229	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.514	0.0885	0.250	1.490	10.14	6.01	Double	0.249	Ti bolt NAS 464-4
230	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.512	0.0883	0.250	2.000	10.09	8.05	Double	0.249	Ti bolt NAS 464-4
231	GI/T300/N5208	37.5/37.5/25	0/45/90/-45/2s	2.513	0.0879	0.251	0.986	10.05	3.94	Double	0.249	Ti bolt NAS 464-4
232	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.506	0.0823	0.249	0.509	10.02	2.04	Double	0.249	Ti bolt NAS 464-4
233	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.506	0.0877	0.250	1.491	9.98	5.94	Double	0.249	Ti bolt NAS 464-4
234	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.507	0.0863	0.249	2.002	10.07	8.04	Double	0.249	Ti bolt NAS 464-4
235	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/s	2.502	0.088	0.257	0.993	10.01	3.97	Double	0.249	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
189	25 RT	Unknown	Unknown	2370	Unknown	108	Unknown	35.4	27.5	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
190	25 RT	Unknown	Unknown	2240	Unknown	108	Unknown	35.3	27.3	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
191	25 RT	Unknown	Unknown	2385	Unknown	111	Unknown	36.7	17.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
192	25 RT	Unknown	Unknown	2525	Unknown	119	Unknown	39.3	14.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
193	25 RT	Unknown	Unknown	2475	Unknown	115	Unknown	37.9	14.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
194	25 RT	Unknown	Unknown	2265	Unknown	105	Unknown	34.8	16.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
195	25 RT	Unknown	Unknown	2380	Unknown	110	Unknown	36.4	28.0	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
196	25 RT	Unknown	Unknown	2450	Unknown	109	Unknown	10.8	26.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
197	25 RT	Unknown	Unknown	2655	Unknown	116	Unknown	11.5	9.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
198	25 RT	Unknown	Unknown	2860	Unknown	119	Unknown	11.8	7.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
199	25 RT	Unknown	Unknown	2950	Unknown	132	Unknown	13.1	16.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
200	25 RT	Unknown	Unknown	2405	Unknown	105	Unknown	10.5	26.0	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
201	25 RT	Unknown	Unknown	2890	Unknown	126	Unknown	12.6	10.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
202	25 RT	Unknown	Unknown	2810	Unknown	124	Unknown	12.3	7.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
203	25 RT	Unknown	Unknown	2920	Unknown	130	Unknown	13.0	15.9	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
204	25 RT	Unknown	Unknown	2225	Unknown	97	Unknown	9.7	24.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
205	25 RT	Unknown	Unknown	2415	Unknown	105	Unknown	10.5	8.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
206	25 RT	Unknown	Unknown	2880	Unknown	125	Unknown	12.4	7.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
207	25 RT	Unknown	Unknown	2985	Unknown	131	Unknown	13.1	16.0	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
208	25 RT	Unknown	Unknown	2310	Unknown	99	Unknown	9.9	24.6	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
209	25 RT	Unknown	Unknown	3110	Unknown	137	Unknown	13.6	11.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
210	25 RT	Unknown	Unknown	3170	Unknown	137	Unknown	13.6	8.5	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
211	25 RT	Unknown	Unknown	2930	Unknown	121	Unknown	12.1	15.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
212	25 RT	Unknown	Unknown	2315	Unknown	102	Unknown	10.1	25.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
213	25 RT	Unknown	Unknown	2770	Unknown	121	Unknown	12.0	10.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
214	25 RT	Unknown	Unknown	2650	Unknown	118	Unknown	11.7	7.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
215	25 RT	Unknown	Unknown	2950	Unknown	132	Unknown	13.0	16.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
216	25 RT	Unknown	Unknown	2380	Unknown	109	Unknown	10.8	26.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
217	25 RT	Unknown	Unknown	2740	Unknown	122	Unknown	12.2	10.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
218	25 RT	Unknown	Unknown	3050	Unknown	136	Unknown	13.5	8.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
219	25 RT	Unknown	Unknown	3020	Unknown	135	Unknown	13.3	16.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
220	25 RT	Unknown	Unknown	2300	Unknown	101	Unknown	10.1	25.0	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
221	25 RT	Unknown	Unknown	2920	Unknown	128	Unknown	12.7	10.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
222	25 RT	Unknown	Unknown	2860	Unknown	126	Unknown	12.5	7.8	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
223	25 RT	Unknown	Unknown	2725	Unknown	120	Unknown	11.9	15.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
224	25 RT	Unknown	Unknown	2115	Unknown	97	Unknown	9.7	24.1	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
225	25 RT	Unknown	Unknown	2620	Unknown	121	Unknown	12.0	10.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
226	25 RT	Unknown	Unknown	2825	Unknown	129	Unknown	12.8	8.0	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
227	25 RT	Unknown	Unknown	2635	Unknown	121	Unknown	12.0	15.1	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
228	25 RT	Unknown	Unknown	2170	Unknown	100	Unknown	9.9	24.7	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
229	25 RT	Unknown	Unknown	2620	Unknown	128	Unknown	12.7	10.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
230	25 RT	Unknown	Unknown	3090	Unknown	141	Unknown	13.9	6.7	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
231	25 RT	Unknown	Unknown	3015	Unknown	138	Unknown	13.6	1.4	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
232	25 RT	Unknown	Unknown	2285	Unknown	112	Unknown	11.1	27.3	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
233	25 RT	Unknown	Unknown	2700	Unknown	124	Unknown	12.3	10.3	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
234	25 RT	Unknown	Unknown	2490	Unknown	116	Unknown	11.5	7.2	Unknown	Bear	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply
235	25 RT	Unknown	Unknown	2820	Unknown	129	Unknown	12.8	16.1	Unknown	Sher	Unknown	Hart-Smith	Hybrid, S-1004 GI for O-Ply

	A	B	C	D	E	F	G	H	I	J	K	L
236	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/1s	2.514	0.0884	0.251	0.505	10.10	2.03	Double	0.249	Ti bolt NAS 464-4
237	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/1s	2.512	0.0852	0.249	1.492	9.77	5.81	Double	0.249	Ti bolt NAS 464-4
238	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/1s	2.508	0.0852	0.250	2.002	9.99	7.98	Double	0.249	Ti bolt NAS 464-4
239	GI/T300/N5208	37.5/50/12.5	0/45/0/-45/90/45/0/-45/1s	2.509	0.0865	0.256	0.990	10.08	3.98	Double	0.249	Ti bolt NAS 464-4
240	T300/N5208	25/50/25	0/45/90/-45/2s	2.507	0.0808	0.2539	0.494	9.87	1.95	Double	0.249	Pin
241	T300/N5208	25/50/25	0/45/90/-45/2s	2.514	0.0914	0.2537	1.495	9.91	5.89	Double	0.249	Pin
242	T300/N5208	25/50/25	0/45/90/-45/2s	2.526	0.0904	0.253	2.003	9.98	7.91	Double	0.249	Pin
243	T300/N5208	25/50/25	0/45/90/-45/2s	2.536	0.0908	0.253	1.007	10.02	3.98	Double	0.249	Pin
244	T300/N5208	25/50/25	0/45/90/-45/2s	2.521	0.0907	0.254	0.494	9.92	1.94	Double	0.249	Pin
245	T300/N5208	25/50/25	0/45/90/-45/2s	2.517	0.0915	0.254	1.489	9.92	5.87	Double	0.249	Pin
246	T300/N5208	25/50/25	0/45/90/-45/2s	2.516	0.0903	0.253	2.006	9.93	7.92	Double	0.249	Pin
247	T300/N5208	25/50/25	0/45/90/-45/2s	2.519	0.0909	0.253	1.007	9.98	3.99	Double	0.249	Pin
248	T300/N5208	25/50/25	0/45/90/-45/2s	0.997	0.1814	0.259	1.016	3.85	3.92	Single	0.249	Ti bolt NAS 464-4
249	T300/N5208	25/50/25	0/45/90/-45/2s	0.997	0.1807	0.258	1.007	3.86	3.90	Single	0.249	Ti bolt NAS 464-4
250	T300/N5208	25/50/25	0/45/90/-45/2s	0.997	0.1810	0.258	1.018	3.86	3.95	Single	0.249	Ti bolt NAS 464-4
251	T300/N5208	25/50/25	0/45/90/-45/2s	0.998	0.1810	0.258	1.014	3.87	3.93	Single	0.249	Ti bolt NAS 464-4
252	M I/N1004	25/50/25	0/45/90/-45/2s	1.251	0.0943	0.250	0.755	5.00	3.02	Double	0.250	Ti bolt NAS 464-4
253	M I/N1004	25/50/25	0/45/90/-45/2s	1.237	0.096	0.250	0.760	4.95	3.04	Double	0.250	Ti bolt NAS 464-4
254	M I/N1004	25/50/25	0/45/90/-45/2s	1.255	0.095	0.250	0.745	5.02	2.98	Double	0.250	Ti bolt NAS 464-4
255	M I/N1004	25/50/25	0/45/90/-45/2s	1.238	0.0895	0.250	1.005	4.95	4.02	Double	0.250	Ti bolt NAS 464-4
256	M I/N1004	25/50/25	0/45/90/-45/2s	1.255	0.091	0.250	1.015	5.02	4.06	Double	0.250	Ti bolt NAS 464-4
257	M I/N1004	25/50/25	0/45/90/-45/2s	1.246	0.0902	0.250	1.010	4.98	4.04	Double	0.250	Ti bolt NAS 464-4
258	M I/N1004	25/50/25	0/45/90/-45/2s	1.232	0.096	0.250	1.516	4.93	6.06	Double	0.250	Ti bolt NAS 464-4
259	M I/N1004	25/50/25	0/45/90/-45/2s	1.259	0.098	0.250	1.505	5.04	6.02	Double	0.250	Ti bolt NAS 464-4
260	M I/N1004	25/50/25	0/45/90/-45/2s	1.248	0.095	0.250	1.510	4.99	6.04	Double	0.250	Ti bolt NAS 464-4
261	M I/N1004	25/50/25	0/45/90/-45/2s	1.256	0.126	0.250	0.755	5.02	3.02	Double	0.250	Ti bolt NAS 464-4
262	M I/N1004	25/50/25	0/45/90/-45/2s	1.257	0.127	0.250	0.745	5.03	2.98	Double	0.250	Ti bolt NAS 464-4
263	M I/N1004	25/50/25	0/45/90/-45/2s	1.250	0.131	0.250	0.755	5.00	3.02	Double	0.250	Ti bolt NAS 464-4
264	M I/N1004	25/50/25	0/45/90/-45/2s	1.231	0.128	0.250	1.005	4.92	4.02	Double	0.250	Ti bolt NAS 464-4
265	M I/N1004	25/50/25	0/45/90/-45/2s	1.232	0.129	0.250	0.994	4.93	3.98	Double	0.250	Ti bolt NAS 464-4
266	M I/N1004	25/50/25	0/45/90/-45/2s	1.256	0.127	0.250	0.995	5.02	3.98	Double	0.250	Ti bolt NAS 464-4
267	M I/N1004	25/50/25	0/45/90/-45/2s	1.226	0.135	0.250	1.510	4.90	6.04	Double	0.250	Ti bolt NAS 464-4
268	M I/N1004	25/50/25	0/45/90/-45/2s	1.258	0.136	0.250	1.510	5.03	6.04	Double	0.250	Ti bolt NAS 464-4
269	M I/N1004	25/50/25	0/45/90/-45/2s	1.258	0.135	0.250	1.506	5.03	6.02	Double	0.250	Ti bolt NAS 464-4
270	M I/N1004	25/50/25	0/45/90/-45/2s	1.258	0.135	0.250	1.506	5.03	6.02	Double	0.250	Ti bolt NAS 464-4
271	M I/N1004	25/50/25	0/45/90/-45/2s	1.240	0.098	0.190	0.505	6.53	2.66	Double	0.250	Ti bolt NAS 464-4
272	M I/N1004	25/50/25	0/45/90/-45/2s	1.253	0.0985	0.190	0.506	6.52	2.66	Double	0.250	Ti bolt NAS 464-4
273	M I/N1004	25/50/25	0/45/90/-45/2s	1.253	0.091	0.190	0.506	6.59	2.66	Double	0.250	Ti bolt NAS 464-4
274	M I/N1004	25/50/25	0/45/90/-45/2s	1.251	0.089	0.190	0.756	6.58	3.98	Double	0.250	Ti bolt NAS 464-4
275	M I/N1004	25/50/25	0/45/90/-45/2s	1.232	0.089	0.190	0.756	6.48	3.98	Double	0.250	Ti bolt NAS 464-4
276	M I/N1004	25/50/25	0/45/90/-45/2s	1.258	0.095	0.192	0.756	6.55	3.94	Double	0.250	Ti bolt NAS 464-4
277	M I/N1004	25/50/25	0/45/90/-45/2s	1.235	0.0918	0.190	1.260	6.50	6.63	Double	0.250	Ti bolt NAS 464-4
278	M I/N1004	25/50/25	0/45/90/-45/2s	1.243	0.0895	0.190	1.255	6.54	6.61	Double	0.250	Ti bolt NAS 464-4
279	M I/N1004	25/50/25	0/45/90/-45/2s	1.257	0.0918	0.190	1.256	6.62	6.61	Double	0.250	Ti bolt NAS 464-4
280	M I/N1004	25/50/25	0/45/90/-45/2s	1.256	0.0135	0.190	0.500	6.62	2.63	Double	0.250	Ti bolt NAS 464-4
281	M I/N1004	25/50/25	0/45/90/-45/2s	1.250	0.0133	0.190	0.495	6.58	2.61	Double	0.250	Ti bolt NAS 464-4
282	M I/N1004	25/50/25	0/45/90/-45/2s	1.259	0.0134	0.190	0.495	6.63	2.61	Double	0.250	Ti bolt NAS 464-4
				1.255	0.0128	0.190	0.760	6.61	4.00	Double	0.250	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
236	25 RT	Unknown	Unknown	2380	Unknown	108	Unknown	10.7	26.7	Unknown	Sher	Unknown	Hart-Smith [1-17]	Hybrid, S-1004 GI for O-Ply
237	25 RT	Unknown	Unknown	2750	Unknown	129	Unknown	12.8	10.8	Unknown	Bear	Unknown	Hart-Smith [1-17]	Hybrid, S-1004 GI for O-Ply
238	25 RT	Unknown	Unknown	2720	Unknown	128	Unknown	12.7	8.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Hybrid, S-1004 GI for O-Ply
239	25 RT	Unknown	Unknown	2685	Unknown	125	Unknown	12.4	15.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Hybrid, S-1004 GI for O-Ply
240	0 RT	Unknown	Unknown	1530	Unknown	68	Unknown	6.7	17.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
241	0 RT	Unknown	Unknown	1500	Unknown	66	Unknown	6.5	5.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
242	0 RT	Unknown	Unknown	1345	Unknown	59	Unknown	6.5	3.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
243	0 RT	Unknown	Unknown	1475	Unknown	65	Unknown	6.4	8.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
244	0 RT	Unknown	Unknown	1500	Unknown	66	Unknown	6.6	16.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
245	0 RT	Unknown	Unknown	1105	Unknown	48	Unknown	4.8	4.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
246	0 RT	Unknown	Unknown	1290	Unknown	57	Unknown	5.7	3.6	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
247	0 RT	Unknown	Unknown	1460	Unknown	64	Unknown	6.4	8.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
248	25 RT	Unknown	Unknown	4390	Unknown	97	Unknown	24.3	11.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
249	25 RT	Unknown	Unknown	4645	Unknown	103	Unknown	25.8	12.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
250	25 RT	Unknown	Unknown	4480	Unknown	99	Unknown	24.8	12.2	Unknown	Tens	Unknown	Hart-Smith [1-17]	Gr/Ep
251	25 RT	Unknown	Unknown	4020	Unknown	89	Unknown	22.3	11.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Gr/Ep
252	25 RT	Unknown	Unknown	3462	Unknown	147	Unknown	29.3	24.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
253	25 RT	Unknown	Unknown	3269	Unknown	136	Unknown	27.5	22.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
254	25 RT	Unknown	Unknown	2788	Unknown	117	Unknown	23.4	19.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
255	25 RT	Unknown	Unknown	3499	Unknown	156	Unknown	31.6	19.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
256	25 RT	Unknown	Unknown	3340	Unknown	147	Unknown	29.2	18.1	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
257	25 RT	Unknown	Unknown	3185	Unknown	141	Unknown	28.3	17.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
258	25 RT	Unknown	Unknown	3509	Unknown	146	Unknown	29.7	12.1	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
259	25 RT	Unknown	Unknown	3809	Unknown	156	Unknown	30.9	12.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
260	25 RT	Unknown	Unknown	3870	Unknown	163	Unknown	32.6	13.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
261	25 RT	Unknown	Unknown	4135	Unknown	131	Unknown	26.1	21.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
262	25 RT	Unknown	Unknown	4752	Unknown	149	Unknown	29.8	25.1	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
263	25 RT	Unknown	Unknown	4520	Unknown	138	Unknown	27.6	22.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
264	25 RT	Unknown	Unknown	5168	Unknown	162	Unknown	32.8	20.1	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
265	25 RT	Unknown	Unknown	4942	Unknown	153	Unknown	31.1	19.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
266	25 RT	Unknown	Unknown	4851	Unknown	153	Unknown	30.4	19.2	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
267	25 RT	Unknown	Unknown	5142	Unknown	152	Unknown	31.1	12.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
268	25 RT	Unknown	Unknown	4785	Unknown	141	Unknown	28.0	11.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
269	25 RT	Unknown	Unknown	4960	Unknown	147	Unknown	29.2	12.2	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
270	25 RT	Unknown	Unknown	2449	Unknown	132	Unknown	20.2	24.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
271	25 RT	Unknown	Unknown	2320	Unknown	127	Unknown	19.4	23.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
272	25 RT	Unknown	Unknown	2357	Unknown	136	Unknown	20.7	25.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
273	25 RT	Unknown	Unknown	2790	Unknown	165	Unknown	25.1	20.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
274	25 RT	Unknown	Unknown	2500	Unknown	148	Unknown	22.8	18.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
275	25 RT	Unknown	Unknown	2837	Unknown	157	Unknown	23.7	19.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
276	25 RT	Unknown	Unknown	2935	Unknown	168	Unknown	25.9	12.7	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
277	25 RT	Unknown	Unknown	2995	Unknown	176	Unknown	26.9	13.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
278	25 RT	Unknown	Unknown	2995	Unknown	172	Unknown	26.0	13.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
279	25 RT	Unknown	Unknown	3470	Unknown	135	Unknown	204.3	257.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
280	25 RT	Unknown	Unknown	3800	Unknown	150	Unknown	228.8	288.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
281	25 RT	Unknown	Unknown	3781	Unknown	149	Unknown	224.1	285.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
282	25 RT	Unknown	Unknown	4111	Unknown	169	Unknown	255.7	211.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II

	A	B	C	D	E	F	G	H	I	J	K	L
283	M I/N1004	25/50/25	0/45/90/-45/2s	1.257	0.0132	0.190	0.755	6.62	3.97	Double	0.250	Ti bolt NAS 464-4
284	M I/N1004	25/50/25	0/45/90/-45/2s	1.256	0.0129	0.190	0.755	6.61	3.97	Double	0.250	Ti bolt NAS 464-4
285	M I/N1004	25/50/25	0/45/90/-45/2s	1.257	0.0129	0.191	1.256	6.58	6.58	Double	0.250	Ti bolt NAS 464-4
286	M I/N1004	25/50/25	0/45/90/-45/2s	1.257	0.0126	0.190	1.255	6.62	6.61	Double	0.250	Ti bolt NAS 464-4
287	M I/N1004	25/50/25	0/45/90/-45/2s	1.251	0.0131	0.190	1.260	6.58	6.63	Double	0.250	Ti bolt NAS 464-4
288	M I/N1004	50/50/0	Unknown	1.247	0.091	0.254	0.750	4.91	2.95	Double	0.250	Ti bolt NAS 464-4
289	M I/N1004	50/50/0	Unknown	1.245	0.09	0.253	0.750	4.92	2.96	Double	0.250	Ti bolt NAS 464-4
290	M I/N1004	50/50/0	Unknown	1.240	0.091	0.254	0.750	4.88	2.95	Double	0.250	Ti bolt NAS 464-4
291	M I/N1004	50/50/0	Unknown	1.241	0.089	0.254	1.016	4.89	4.00	Double	0.250	Ti bolt NAS 464-4
292	M I/N1004	50/50/0	Unknown	1.245	0.091	0.253	1.016	4.92	4.02	Double	0.250	Ti bolt NAS 464-4
293	M I/N1004	50/50/0	Unknown	1.249	0.08	0.254	1.000	4.92	3.94	Double	0.250	Ti bolt NAS 464-4
294	M I/N1004	50/50/0	Unknown	1.259	0.091	0.254	1.516	4.96	5.97	Double	0.250	Ti bolt NAS 464-4
295	M I/N1004	50/50/0	Unknown	1.282	0.093	0.253	1.516	4.99	5.99	Double	0.250	Ti bolt NAS 464-4
296	M I/N1004	50/50/0	Unknown	1.255	0.091	0.253	1.516	4.96	2.98	Double	0.250	Ti bolt NAS 464-4
297	M I/N1004	50/50/0	Unknown	1.253	0.131	0.254	0.754	4.93	2.98	Double	0.250	Ti bolt NAS 464-4
298	M I/N1004	50/50/0	Unknown	1.253	0.132	0.254	0.756	4.93	2.97	Double	0.250	Ti bolt NAS 464-4
299	M I/N1004	50/50/0	Unknown	1.258	0.128	0.253	0.755	4.97	3.98	Double	0.250	Ti bolt NAS 464-4
300	M I/N1004	50/50/0	Unknown	1.253	0.126	0.253	1.008	4.95	3.98	Double	0.250	Ti bolt NAS 464-4
301	M I/N1004	50/50/0	Unknown	1.253	0.126	0.254	1.008	4.93	3.84	Double	0.250	Ti bolt NAS 464-4
302	M I/N1004	50/50/0	Unknown	1.253	0.124	0.254	1.002	4.93	5.92	Double	0.250	Ti bolt NAS 464-4
303	M I/N1004	50/50/0	Unknown	1.252	0.128	0.254	1.504	4.93	5.93	Double	0.250	Ti bolt NAS 464-4
304	M I/N1004	50/50/0	Unknown	1.252	0.126	0.254	1.507	4.93	5.93	Double	0.250	Ti bolt NAS 464-4
305	M I/N1004	50/50/0	Unknown	1.252	0.128	0.254	1.505	4.93	5.93	Double	0.250	Ti bolt NAS 464-4
306	M I/N1004	50/50/0	Unknown	1.244	0.092	0.190	0.515	6.55	2.71	Double	0.250	Ti bolt NAS 464-4
307	M I/N1004	50/50/0	Unknown	1.242	0.094	0.193	0.500	6.44	2.59	Double	0.250	Ti bolt NAS 464-4
308	M I/N1004	50/50/0	Unknown	1.250	0.094	0.192	0.500	6.51	2.60	Double	0.250	Ti bolt NAS 464-4
309	M I/N1004	50/50/0	Unknown	1.245	0.092	0.190	0.735	6.55	3.87	Double	0.250	Ti bolt NAS 464-4
310	M I/N1004	50/50/0	Unknown	1.243	0.094	0.191	0.768	6.51	4.01	Double	0.250	Ti bolt NAS 464-4
311	M I/N1004	50/50/0	Unknown	1.248	0.093	0.190	0.766	6.57	4.03	Double	0.250	Ti bolt NAS 464-4
312	M I/N1004	50/50/0	Unknown	1.255	0.092	0.190	1.281	6.61	6.74	Double	0.250	Ti bolt NAS 464-4
313	M I/N1004	50/50/0	Unknown	1.256	0.091	0.190	1.281	6.61	6.74	Double	0.250	Ti bolt NAS 464-4
314	M I/N1004	50/50/0	Unknown	1.267	0.091	0.190	1.268	6.67	6.66	Double	0.250	Ti bolt NAS 464-4
315	M I/N1004	50/50/0	Unknown	1.252	0.124	0.190	0.499	6.59	2.63	Double	0.250	Ti bolt NAS 464-4
316	M I/N1004	50/50/0	Unknown	1.252	0.128	0.190	0.503	6.59	2.65	Double	0.250	Ti bolt NAS 464-4
317	M I/N1004	50/50/0	Unknown	1.252	0.125	0.190	0.504	6.59	2.65	Double	0.250	Ti bolt NAS 464-4
318	M I/N1004	50/50/0	Unknown	1.252	0.125	0.190	0.757	6.59	3.98	Double	0.250	Ti bolt NAS 464-4
319	M I/N1004	50/50/0	Unknown	1.253	0.126	0.190	0.750	6.59	3.95	Double	0.250	Ti bolt NAS 464-4
320	M I/N1004	50/50/0	Unknown	1.253	0.124	0.190	0.755	6.59	3.97	Double	0.250	Ti bolt NAS 464-4
321	M I/N1004	50/50/0	Unknown	1.259	0.132	0.190	1.259	6.63	6.63	Double	0.250	Ti bolt NAS 464-4
322	M I/N1004	50/50/0	Unknown	1.254	0.133	0.190	1.254	6.60	6.60	Double	0.250	Ti bolt NAS 464-4
323	M I/N1004	50/50/0	Unknown	1.253	0.131	0.190	1.262	6.59	6.64	Double	0.250	Ti bolt NAS 464-4
324	M I/N1004	25/75/0	Unknown	2.520	0.175	0.250	0.512	10.08	2.05	Double	0.250	Ti bolt NAS 464-4
325	M I/N1004	25/75/0	Unknown	2.521	0.173	0.250	0.508	10.08	2.03	Double	0.250	Ti bolt NAS 464-4
326	M I/N1004	25/75/0	Unknown	2.520	0.175	0.250	1.493	10.08	5.97	Double	0.250	Ti bolt NAS 464-4
327	M I/N1004	25/75/0	Unknown	2.521	0.173	0.250	1.490	10.08	5.98	Double	0.250	Ti bolt NAS 464-4
328	M I/N1004	25/75/0	Unknown	2.499	0.17	0.250	0.515	10.00	2.06	Double	0.250	Ti bolt NAS 464-4
329	M I/N1004	25/75/0	Unknown	2.494	0.175	0.250	0.512	9.98	2.05	Double	0.250	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
283	25 RT	Unknown	Unknown	3745	Unknown	149	Unknown	225.7	187.9	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
284	25 RT	Unknown	Unknown	3825	Unknown	156	Unknown	236.1	196.4	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
285	25 RT	Unknown	Unknown	4222	Unknown	172	Unknown	260.4	130.3	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
286	25 RT	Unknown	Unknown	4000	Unknown	167	Unknown	252.6	126.5	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
287	25 RT	Unknown	Unknown	4595	Unknown	185	Unknown	280.4	139.2	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
288	25 RT	Unknown	Unknown	3205	Unknown	141	Unknown	28.2	23.5	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
289	25 RT	Unknown	Unknown	2915	Unknown	129	Unknown	26.0	21.6	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
290	25 RT	Unknown	Unknown	3102	Unknown	136	Unknown	27.5	22.7	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
291	25 RT	Unknown	Unknown	3319	Unknown	149	Unknown	30.1	18.4	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
292	25 RT	Unknown	Unknown	3571	Unknown	157	Unknown	31.5	19.3	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
293	25 RT	Unknown	Unknown	3440	Unknown	153	Unknown	30.6	19.1	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
294	25 RT	Unknown	Unknown	3340	Unknown	147	Unknown	29.2	12.1	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
295	25 RT	Unknown	Unknown	3538	Unknown	152	Unknown	30.1	12.5	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
296	25 RT	Unknown	Unknown	3465	Unknown	152	Unknown	30.3	12.6	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
297	25 RT	Unknown	Unknown	3800	Unknown	116	Unknown	23.2	19.2	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
298	25 RT	Unknown	Unknown	3755	Unknown	114	Unknown	22.7	18.8	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
299	25 RT	Unknown	Unknown	4365	Unknown	135	Unknown	26.9	22.4	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
300	25 RT	Unknown	Unknown	4735	Unknown	150	Unknown	30.0	18.7	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
301	25 RT	Unknown	Unknown	4755	Unknown	151	Unknown	30.1	18.7	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
302	25 RT	Unknown	Unknown	4175	Unknown	135	Unknown	26.9	16.8	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
303	25 RT	Unknown	Unknown	4380	Unknown	139	Unknown	27.8	11.8	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
304	25 RT	Unknown	Unknown	4450	Unknown	139	Unknown	27.6	11.5	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
305	25 RT	Unknown	Unknown	4820	Unknown	153	Unknown	30.6	12.7	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
306	25 RT	Unknown	Unknown	2098	Unknown	120	Unknown	18.3	22.1	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
307	25 RT	Unknown	Unknown	2080	Unknown	114	Unknown	17.8	22.1	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
308	25 RT	Unknown	Unknown	2068	Unknown	116	Unknown	17.6	22.0	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
309	25 RT	Unknown	Unknown	2450	Unknown	140	Unknown	21.4	18.1	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
310	25 RT	Unknown	Unknown	2429	Unknown	136	Unknown	20.8	16.9	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
311	25 RT	Unknown	Unknown	2310	Unknown	131	Unknown	19.9	16.2	Unknown	Sher	Unknown	Hart-Smith	Fiber: Morganite II
312	25 RT	Unknown	Unknown	2665	Unknown	153	Unknown	23.1	11.3	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
313	25 RT	Unknown	Unknown	2523	Unknown	146	Unknown	22.1	10.8	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
314	25 RT	Unknown	Unknown	2542	Unknown	147	Unknown	22.0	11.0	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
315	25 RT	Unknown	Unknown	2895	Unknown	123	Unknown	18.6	23.4	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
316	25 RT	Unknown	Unknown	3040	Unknown	125	Unknown	19.0	23.6	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
317	25 RT	Unknown	Unknown	2787	Unknown	117	Unknown	17.8	22.1	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
318	25 RT	Unknown	Unknown	3755	Unknown	158	Unknown	24.0	19.8	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
319	25 RT	Unknown	Unknown	3515	Unknown	147	Unknown	22.3	18.6	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
320	25 RT	Unknown	Unknown	3262	Unknown	139	Unknown	21.0	17.4	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
321	25 RT	Unknown	Unknown	3996	Unknown	159	Unknown	24.0	12.0	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
322	25 RT	Unknown	Unknown	4015	Unknown	159	Unknown	24.1	12.0	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
323	25 RT	Unknown	Unknown	3660	Unknown	155	Unknown	23.5	11.7	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
324	25 RT	Unknown	Unknown	4070	Unknown	93	Unknown	9.2	22.7	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
325	25 RT	Unknown	Unknown	3420	Unknown	79	Unknown	7.8	19.5	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
326	25 RT	Unknown	Unknown	6660	Unknown	152	Unknown	15.1	12.7	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
327	25 RT	Unknown	Unknown	6420	Unknown	148	Unknown	14.7	12.5	Unknown	Bear	Unknown	Hart-Smith	Fiber: Morganite II
328	25 RT	Unknown	Unknown	3370	Unknown	79	Unknown	7.9	19.2	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II
329	25 RT	Unknown	Unknown	4140	Unknown	95	Unknown	9.5	23.1	Unknown	Tens	Unknown	Hart-Smith	Fiber: Morganite II

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
330M	11N1004	25/75/0	Unknown	2.499	0.17	0.250	1.494	10.00	5.98	Double	0.250	Ti bolt NAS 464-4
331M	11N1004	25/75/0	Unknown	2.494	0.175	0.250	1.493	9.98	5.97	Double	0.250	Ti bolt NAS 464-4
332M	11N1004	50/50/0	Unknown	2.498	0.177	0.250	0.511	9.99	2.04	Double	0.250	Ti bolt NAS 464-4
333M	11N1004	50/50/0	Unknown	2.500	0.178	0.250	0.504	10.00	2.02	Double	0.250	Ti bolt NAS 464-4
334M	11N1004	50/50/0	Unknown	2.498	0.177	0.250	1.868	9.99	7.47	Double	0.250	Ti bolt NAS 464-4
335M	11N1004	50/50/0	Unknown	2.500	0.178	0.250	1.868	10.00	7.47	Double	0.250	Ti bolt NAS 464-4
336M	11N1004	50/50/0	Unknown	2.476	0.175	0.250	0.503	9.90	2.01	Double	0.250	Ti bolt NAS 464-4
337M	11N1004	50/50/0	Unknown	2.506	0.176	0.250	0.499	10.02	2.00	Double	0.250	Ti bolt NAS 464-4
338M	11N1004	50/50/0	Unknown	2.476	0.175	0.250	1.867	9.90	7.47	Double	0.250	Ti bolt NAS 464-4
339M	11N1004	50/50/0	Unknown	2.506	0.176	0.250	1.867	10.02	7.47	Double	0.250	Ti bolt NAS 464-4
340M	11N1004	75/25/0	Unknown	1.996	0.172	0.250	0.490	7.98	1.96	Double	0.250	Ti bolt NAS 464-4
341M	11N1004	75/25/0	Unknown	1.999	0.173	0.250	0.505	8.00	2.02	Double	0.250	Ti bolt NAS 464-4
342M	11N1004	75/25/0	Unknown	1.996	0.172	0.250	2.366	7.98	9.46	Double	0.250	Ti bolt NAS 464-4
343M	11N1004	75/25/0	Unknown	1.999	0.173	0.250	2.367	8.00	9.47	Double	0.250	Ti bolt NAS 464-4
344M	11N1004	75/25/0	Unknown	2.002	0.173	0.250	0.501	8.01	2.00	Double	0.250	Ti bolt NAS 464-4
345M	11N1004	75/25/0	Unknown	1.995	0.172	0.250	0.510	7.98	2.04	Double	0.250	Ti bolt NAS 464-4
346M	11N1004	75/25/0	Unknown	2.002	0.173	0.250	2.366	8.01	9.46	Double	0.250	Ti bolt NAS 464-4
347M	11N1004	75/25/0	Unknown	1.995	0.172	0.250	2.366	7.98	9.46	Double	0.250	Ti bolt NAS 464-4
348M	11N1004	25/62.5/12.5	Unknown	2.496	0.174	0.250	0.513	9.98	2.08	Double	0.250	Ti bolt NAS 464-4
349M	11N1004	25/62.5/12.5	Unknown	2.497	0.174	0.250	0.505	9.99	2.02	Double	0.250	Ti bolt NAS 464-4
350M	11N1004	25/62.5/12.5	Unknown	2.496	0.174	0.250	1.867	9.98	7.47	Double	0.250	Ti bolt NAS 464-4
351M	11N1004	25/62.5/12.5	Unknown	2.497	0.174	0.250	1.868	9.99	7.47	Double	0.250	Ti bolt NAS 464-4
352M	11N1004	25/62.5/12.5	Unknown	2.495	0.172	0.250	0.500	9.98	2.00	Double	0.250	Ti bolt NAS 464-4
353M	11N1004	25/62.5/12.5	Unknown	2.491	0.176	0.250	0.521	9.98	2.08	Double	0.250	Ti bolt NAS 464-4
354M	11N1004	25/62.5/12.5	Unknown	2.495	0.177	0.250	1.866	9.99	7.46	Double	0.250	Ti bolt NAS 464-4
355M	11N1004	25/62.5/12.5	Unknown	2.494	0.176	0.250	1.863	9.96	7.45	Double	0.250	Ti bolt NAS 464-4
356M	11N1004	50/37.5/12.5	Unknown	2.485	0.176	0.250	0.514	9.94	2.06	Double	0.250	Ti bolt NAS 464-4
357M	11N1004	50/37.5/12.5	Unknown	2.484	0.176	0.250	0.513	9.94	2.05	Double	0.250	Ti bolt NAS 464-4
358M	11N1004	50/37.5/12.5	Unknown	2.483	0.176	0.250	1.866	9.94	7.46	Double	0.250	Ti bolt NAS 464-4
359M	11N1004	50/37.5/12.5	Unknown	2.484	0.176	0.250	1.867	9.94	7.47	Double	0.250	Ti bolt NAS 464-4
360M	11N1004	50/37.5/12.5	Unknown	2.502	0.176	0.250	0.504	10.01	2.02	Double	0.250	Ti bolt NAS 464-4
361M	11N1004	50/37.5/12.5	Unknown	2.499	0.176	0.250	0.491	10.03	1.98	Double	0.250	Ti bolt NAS 464-4
362M	11N1004	50/37.5/12.5	Unknown	2.492	0.176	0.250	1.866	10.01	7.46	Double	0.250	Ti bolt NAS 464-4
363M	11N1004	50/37.5/12.5	Unknown	2.503	0.176	0.250	1.867	10.03	7.47	Double	0.250	Ti bolt NAS 464-4
364M	11N1004	75/12.5/12.5	Unknown	2.002	0.178	0.250	0.492	8.01	1.97	Double	0.250	Ti bolt NAS 464-4
365M	11N1004	75/12.5/12.5	Unknown	1.994	0.170	0.250	0.485	7.98	1.94	Double	0.250	Ti bolt NAS 464-4
366M	11N1004	75/12.5/12.5	Unknown	2.002	0.178	0.250	2.365	8.01	9.46	Double	0.250	Ti bolt NAS 464-4
367M	11N1004	75/12.5/12.5	Unknown	1.994	0.178	0.250	2.366	7.98	9.46	Double	0.250	Ti bolt NAS 464-4
368M	11N1004	75/12.5/12.5	Unknown	2.001	0.177	0.250	0.490	8.00	1.96	Double	0.250	Ti bolt NAS 464-4
369M	11N1004	75/12.5/12.5	Unknown	1.997	0.178	0.250	0.474	7.99	1.90	Double	0.250	Ti bolt NAS 464-4
370M	11N1004	75/12.5/12.5	Unknown	2.001	0.177	0.250	2.367	8.00	9.47	Double	0.250	Ti bolt NAS 464-4
371M	11N1004	75/12.5/12.5	Unknown	1.997	0.170	0.250	2.366	7.99	9.48	Double	0.250	Ti bolt NAS 464-4
372M	11N1004	25/50/25	Unknown	2.502	0.172	0.250	0.503	10.01	2.01	Double	0.250	Ti bolt NAS 464-4
373M	11N1004	25/50/25	Unknown	2.500	0.171	0.250	0.504	10.00	2.02	Double	0.250	Ti bolt NAS 464-4
374M	11N1004	25/50/25	Unknown	2.502	0.172	0.250	1.867	10.01	7.47	Double	0.250	Ti bolt NAS 464-4
375M	11N1004	25/50/25	Unknown	2.500	0.171	0.250	1.866	10.00	7.46	Double	0.250	Ti bolt NAS 464-4
376M	11N1004	25/50/25	Unknown	2.493	0.172	0.250	0.498	9.97	2.00	Double	0.250	Ti bolt NAS 464-4

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
330	25 RT	Unknown	Unknown	6450	Unknown	152	Unknown	15.2	12.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
331	25 RT	Unknown	Unknown	5720	Unknown	131	Unknown	13.1	10.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
332	25 RT	Unknown	Unknown	3410	Unknown	77	Unknown	7.7	18.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
333	25 RT	Unknown	Unknown	3705	Unknown	83	Unknown	8.3	20.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
334	25 RT	Unknown	Unknown	6080	Unknown	137	Unknown	13.8	9.2	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
335	25 RT	Unknown	Unknown	5990	Unknown	135	Unknown	13.5	9.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
336	25 RT	Unknown	Unknown	3160	Unknown	72	Unknown	7.3	17.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
337	25 RT	Unknown	Unknown	3080	Unknown	69	Unknown	6.9	17.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
338	25 RT	Unknown	Unknown	6520	Unknown	149	Unknown	15.0	10.0	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
339	25 RT	Unknown	Unknown	6330	Unknown	144	Unknown	14.4	9.6	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
340	25 RT	Unknown	Unknown	1815	Unknown	42	Unknown	5.3	10.8	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
341	25 RT	Unknown	Unknown	2180	Unknown	50	Unknown	6.3	12.5	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
342	25 RT	Unknown	Unknown	5540	Unknown	129	Unknown	16.1	6.8	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
343	25 RT	Unknown	Unknown	5640	Unknown	130	Unknown	16.3	6.9	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
344	25 RT	Unknown	Unknown	1920	Unknown	44	Unknown	5.5	11.1	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
345	25 RT	Unknown	Unknown	2385	Unknown	54	Unknown	6.8	13.2	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
346	25 RT	Unknown	Unknown	5370	Unknown	124	Unknown	15.5	6.6	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
347	25 RT	Unknown	Unknown	5230	Unknown	118	Unknown	14.8	6.2	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
348	25 RT	Unknown	Unknown	4160	Unknown	96	Unknown	9.6	23.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
349	25 RT	Unknown	Unknown	4470	Unknown	103	Unknown	10.3	25.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
350	25 RT	Unknown	Unknown	6460	Unknown	149	Unknown	14.9	9.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
351	25 RT	Unknown	Unknown	6230	Unknown	143	Unknown	14.3	9.6	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
352	25 RT	Unknown	Unknown	3990	Unknown	90	Unknown	9.0	22.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
353	25 RT	Unknown	Unknown	4555	Unknown	104	Unknown	10.4	24.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
354	25 RT	Unknown	Unknown	6520	Unknown	147	Unknown	14.8	9.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
355	25 RT	Unknown	Unknown	5570	Unknown	127	Unknown	12.7	8.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
356	25 RT	Unknown	Unknown	3020	Unknown	69	Unknown	6.9	16.7	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
357	25 RT	Unknown	Unknown	3220	Unknown	73	Unknown	7.4	17.0	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
358	25 RT	Unknown	Unknown	6750	Unknown	153	Unknown	15.4	10.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
359	25 RT	Unknown	Unknown	6177	Unknown	140	Unknown	14.1	9.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
360	25 RT	Unknown	Unknown	3260	Unknown	74	Unknown	7.4	18.4	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
361	25 RT	Unknown	Unknown	3230	Unknown	73	Unknown	7.3	18.7	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
362	25 RT	Unknown	Unknown	6240	Unknown	142	Unknown	14.2	9.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
363	25 RT	Unknown	Unknown	6200	Unknown	141	Unknown	14.0	9.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
364	25 RT	Unknown	Unknown	2015	Unknown	45	Unknown	5.7	11.5	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
365	25 RT	Unknown	Unknown	1965	Unknown	44	Unknown	5.5	11.4	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
366	25 RT	Unknown	Unknown	5720	Unknown	129	Unknown	16.1	6.8	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
367	25 RT	Unknown	Unknown	5970	Unknown	134	Unknown	16.8	7.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
368	25 RT	Unknown	Unknown	1650	Unknown	37	Unknown	4.7	9.5	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
369	25 RT	Unknown	Unknown	1840	Unknown	41	Unknown	5.2	10.9	Unknown	Clev	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
370	25 RT	Unknown	Unknown	5450	Unknown	123	Unknown	15.4	6.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
371	25 RT	Unknown	Unknown	6170	Unknown	139	Unknown	17.4	7.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
372	25 RT	Unknown	Unknown	3210	Unknown	75	Unknown	7.5	18.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
373	25 RT	Unknown	Unknown	3600	Unknown	84	Unknown	8.4	20.8	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
374	25 RT	Unknown	Unknown	6030	Unknown	140	Unknown	14.0	9.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
375	25 RT	Unknown	Unknown	6570	Unknown	154	Unknown	15.4	10.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
376	25 RT	Unknown	Unknown	3680	Unknown	86	Unknown	8.6	21.4	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
377M	I/N1004	25/50/25	Unknown	2.497	0.171	0.250	1.866	9.99	7.46	Double	0.250	Ti bolt NAS 464-4
378M	I/N1004	25/50/25	Unknown	2.493	0.172	0.250	1.869	9.97	7.48	Double	0.250	Ti bolt NAS 464-4
379M	I/N1004	50/25/25	Unknown	2.498	0.178	0.250	0.512	9.99	2.05	Double	0.250	Ti bolt NAS 464-4
380M	I/N1004	50/25/25	Unknown	2.499	0.175	0.250	0.503	10.00	2.01	Double	0.250	Ti bolt NAS 464-4
381M	I/N1004	50/25/25	Unknown	2.498	0.178	0.250	1.865	9.99	7.46	Double	0.250	Ti bolt NAS 464-4
382M	I/N1004	50/25/25	Unknown	2.499	0.175	0.250	1.866	10.00	7.46	Double	0.250	Ti bolt NAS 464-4
383M	I/N1004	50/25/25	Unknown	2.497	0.172	0.250	0.517	9.99	2.07	Double	0.250	Ti bolt NAS 464-4
384M	I/N1004	50/25/25	Unknown	2.497	0.171	0.250	0.508	9.99	2.03	Double	0.250	Ti bolt NAS 464-4
385M	I/N1004	50/25/25	Unknown	2.497	0.172	0.250	1.866	9.99	7.46	Double	0.250	Ti bolt NAS 464-4
386M	I/N1004	50/25/25	Unknown	2.497	0.171	0.250	1.864	9.99	7.46	Double	0.250	Ti bolt NAS 464-4
387M	I/N1004	75/0/25	Unknown	2.006	0.178	0.250	0.49	8.02	1.96	Double	0.250	Ti bolt NAS 464-4
388M	I/N1004	75/0/25	Unknown	2.005	0.178	0.250	0.51	8.02	2.04	Double	0.250	Ti bolt NAS 464-4
389M	I/N1004	75/0/25	Unknown	2.006	0.178	0.250	2.367	8.02	9.47	Double	0.250	Ti bolt NAS 464-4
390M	I/N1004	75/0/25	Unknown	2.005	0.178	0.250	2.364	8.02	9.46	Double	0.250	Ti bolt NAS 464-4
391M	I/N1004	75/0/25	Unknown	2.002	0.179	0.250	0.495	8.01	1.98	Double	0.250	Ti bolt NAS 464-4
392M	I/N1004	75/0/25	Unknown	2.001	0.177	0.250	0.46	8.01	1.84	Double	0.250	Ti bolt NAS 464-4
393M	I/N1004	75/0/25	Unknown	2.002	0.179	0.250	2.369	8.01	9.48	Double	0.250	Ti bolt NAS 464-4
394M	I/N1004	75/0/25	Unknown	2.001	0.177	0.250	2.364	8.00	9.46	Double	0.250	Ti bolt NAS 464-4
395M	I/N1004	0/100/0	Unknown	2.506	0.180	0.250	0.497	10.04	1.99	Double	0.250	Ti bolt NAS 464-4
396M	I/N1004	0/100/0	Unknown	2.506	0.180	0.250	0.489	10.03	1.96	Double	0.250	Ti bolt NAS 464-4
397M	I/N1004	0/100/0	Unknown	2.509	0.180	0.250	1.667	10.04	6.67	Double	0.250	Ti bolt NAS 464-4
398M	I/N1004	0/100/0	Unknown	2.508	0.180	0.250	1.16	10.03	4.72	Double	0.250	Ti bolt NAS 464-4
399M	I/N1004	0/100/0	Unknown	2.496	0.180	0.250	0.498	9.99	1.99	Double	0.250	Ti bolt NAS 464-4
400M	I/N1004	0/100/0	Unknown	2.496	0.178	0.250	0.506	9.96	2.02	Double	0.250	Ti bolt NAS 464-4
401M	I/N1004	0/100/0	Unknown	2.496	0.180	0.250	1.23	9.99	4.92	Double	0.250	Ti bolt NAS 464-4
402M	I/N1004	0/100/0	Unknown	2.498	0.178	0.250	1.205	9.98	4.82	Double	0.250	Ti bolt NAS 464-4
403M	AS1/3501-8	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.510	0.212	0.251	0.75	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
404M	AS1/3501-8	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.510	0.212	0.249	0.73	6.06	3.01	Double	0.249	ST3M 453-4-26 bolt
405M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.510	0.212	0.249	0.75	6.06	3.01	Double	0.249	ST3M 453-4-26 bolt
406M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.510	0.212	0.251	0.75	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
407M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.229	0.249	0.75	5.95	3.01	Double	0.249	ST3M 453-4-26 bolt
408M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.481	0.229	0.249	0.75	5.95	3.01	Double	0.249	ST3M 453-4-26 bolt
409M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.481	0.229	0.250	0.75	5.92	3.00	Double	0.249	ST3M 453-4-26 bolt
410M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.481	0.229	0.250	0.75	5.92	3.00	Double	0.249	ST3M 453-4-26 bolt
411M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.197	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
412M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.197	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
413M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.197	0.249	0.75	6.04	3.01	Double	0.249	ST3M 453-4-26 bolt
414M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.197	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
415M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.503	0.208	0.249	0.75	6.04	3.01	Double	0.249	ST3M 453-4-26 bolt
416M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.505	0.203	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
417M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.506	0.207	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
418M	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.507	0.213	0.250	0.75	6.03	3.00	Double	0.249	ST3M 453-4-26 bolt
419M	AS1/3501-6	50/40/10	[45/-45/0/2/45/90/-45/0]3s	1.513	0.195	0.251	0.75	6.03	2.99	Double	0.249	ST3M 453-4-26 bolt
420M	AS1/3501-6	50/40/10	[45/-45/0/2/45/90/-45/0]3s	1.513	0.195	0.249	0.75	6.08	3.01	Double	0.249	ST3M 453-4-26 bolt
421M	AS1/3501-6	50/40/10	[45/-45/0/2/45/90/-45/0]3s	1.513	0.195	0.251	0.75	6.03	2.99	Double	0.249	ST3M 453-4-26 bolt
422M	AS1/3501-6	50/40/10	[45/-45/0/2/45/90/-45/0]3s	1.513	0.185	0.250	0.75	6.05	3.00	Double	0.249	ST3M 453-4-26 bolt
423M	AS1/3501-6	50/40/10	[45/-45/0/2/45/90/-45/0]3s	1.507	0.193	0.250	0.75	6.03	3.00	Double	0.249	ST3M 453-4-26 bolt

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
377	25 RT	Unknown	Unknown	6380	Unknown	149	Unknown	14.9	10.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
378	25 RT	Unknown	Unknown	5990	Unknown	139	Unknown	14.0	9.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
379	25 RT	Unknown	Unknown	2980	Unknown	67	Unknown	6.7	16.3	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
380	25 RT	Unknown	Unknown	3085	Unknown	71	Unknown	7.1	17.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
381	25 RT	Unknown	Unknown	6585	Unknown	148	Unknown	14.8	9.9	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
382	25 RT	Unknown	Unknown	6110	Unknown	139	Unknown	14.0	9.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
383	25 RT	Unknown	Unknown	3025	Unknown	70	Unknown	7.0	17.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
384	25 RT	Unknown	Unknown	2980	Unknown	69	Unknown	7.0	17.2	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
385	25 RT	Unknown	Unknown	6400	Unknown	149	Unknown	14.9	10.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
386	25 RT	Unknown	Unknown	6470	Unknown	151	Unknown	15.2	10.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
387	25 RT	Unknown	Unknown	2290	Unknown	52	Unknown	6.4	13.1	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
388	25 RT	Unknown	Unknown	2040	Unknown	45	Unknown	5.7	11.2	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
389	25 RT	Unknown	Unknown	6230	Unknown	140	Unknown	17.4	7.4	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
390	25 RT	Unknown	Unknown	5910	Unknown	133	Unknown	16.6	7.0	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
391	25 RT	Unknown	Unknown	2130	Unknown	48	Unknown	5.9	12.0	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
392	25 RT	Unknown	Unknown	2200	Unknown	49	Unknown	6.2	13.5	Unknown	Sher	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
393	25 RT	Unknown	Unknown	6340	Unknown	142	Unknown	17.7	7.5	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
394	25 RT	Unknown	Unknown	6090	Unknown	138	Unknown	17.2	7.3	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
395	25 RT	Unknown	Unknown	3325	Unknown	74	Unknown	7.4	18.6	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
396	25 RT	Unknown	Unknown	3150	Unknown	70	Unknown	7.0	17.9	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
397	25 RT	Unknown	Unknown	3445	Unknown	77	Unknown	7.6	5.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
398	25 RT	Unknown	Unknown	3240	Unknown	72	Unknown	7.2	7.6	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
399	25 RT	Unknown	Unknown	3130	Unknown	69	Unknown	7.0	17.5	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
400	25 RT	Unknown	Unknown	3250	Unknown	73	Unknown	7.3	18.0	Unknown	Tens	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
401	25 RT	Unknown	Unknown	3130	Unknown	69	Unknown	7.0	7.1	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
402	25 RT	Unknown	Unknown	3290	Unknown	74	Unknown	7.4	7.7	Unknown	Bear	Unknown	Hart-Smith [1-17]	Fiber: Morganite II
403	0 RT	0.00	0.00	6880	Unknown	129	Unknown	21.5	21.6	1950 Sh & Br	1950 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
404	0 RT	0.00	0.00	7330	Unknown	139	Unknown	22.9	23.1	2060 Sh & Br	2060 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
405	0 RT	0.00	0.00	7620	Unknown	144	Unknown	23.8	24.0	2135 Sh & Br	2135 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
406	0 RT	0.00	0.00	7380	Unknown	139	Unknown	23.1	23.2	2140 Sh & Br	2140 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
407	0 RT	0.00	0.00	6240	Unknown	109	Unknown	18.4	18.2	1625 Sh & Br	1625 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
408	0 RT	0.00	0.00	6420	Unknown	112	Unknown	18.9	18.7	1715 Sh & Br	1715 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
409	0 RT	0.00	0.00	6420	Unknown	112	Unknown	18.9	18.7	1810 Sh & Br	1810 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
410	0 RT	0.00	0.00	6840	Unknown	119	Unknown	20.2	19.9	1915 Sh & Br	1915 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
411	25 RT	0.00	0.00	7160	Unknown	145	Unknown	24.1	24.2	2160 Sh & Br	2160 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
412	25 RT	0.00	0.00	6900	Unknown	140	Unknown	23.2	23.3	2050 Sh & Br	2050 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
413	25 RT	0.00	0.00	7010	Unknown	143	Unknown	23.6	23.7	2110 Sh & Br	2110 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
414	25 RT	0.00	0.00	6910	Unknown	140	Unknown	23.3	23.3	2105 Sh & Br	2105 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
415	0 250 F	0.82	0.82	3980	Unknown	77	Unknown	12.8	12.8	1190 Sh & Br	1190 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
416	0 250 F	0.78	0.78	4060	Unknown	81	Unknown	13.4	13.4	1260 Sh & Br	1260 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
417	0 250 F	0.80	0.80	4720	Unknown	91	Unknown	15.1	15.2	1370 Sh & Br	1370 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
418	0 250 F	0.86	0.86	5280	Unknown	99	Unknown	16.4	16.5	1520 Sh & Br	1520 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
419	50 RT	0.00	0.00	6310	Unknown	129	Unknown	21.4	21.6	1900 Sh & Br	1900 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
420	50 RT	0.00	0.00	6840	Unknown	137	Unknown	22.5	22.7	2030 Sh & Br	2030 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
421	50 RT	0.00	0.00	6500	Unknown	133	Unknown	22.0	22.2	2075 Sh & Br	2075 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
422	50 RT	0.00	0.00	6730	Unknown	136	Unknown	22.8	23.0	2245 Sh & Br	2245 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep
423	50 250 F	0.75	0.75	2460	Unknown	51	Unknown	8.5	8.5	760 Sh & Br	760 Sh & Br	Unknown	Carbo et al [1-38]	Gr/Ep

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
424	AS1/3501-6	50/40/10	[45/-45/(0)2/45/90/-45/(0)3]s	1.507	0.193	0.251	0.75	6.00	2.99	Double	0.249	ST3M 453-4-26 bolt
425	AS1/3501-6	50/40/10	[45/-45/(0)2/45/90/-45/(0)3]s	1.504	0.201	0.249	0.75	6.04	3.01	Double	0.249	ST3M 453-4-26 bolt
426	AS1/3501-6	50/40/10	[45/-45/(0)2/45/90/-45/(0)3]s	1.505	0.204	0.248	0.75	6.07	3.02	Double	0.249	ST3M 453-4-26 bolt
427	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.512	0.189	0.251	0.75	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
428	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.512	0.189	0.249	0.75	6.07	3.01	Double	0.249	ST3M 453-4-26 bolt
429	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.512	0.189	0.250	0.75	6.05	3.00	Double	0.249	ST3M 453-4-26 bolt
430	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.512	0.189	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
431	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.506	0.186	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
432	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.505	0.183	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
433	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.503	0.193	0.249	0.75	6.04	3.01	Double	0.249	ST3M 453-4-26 bolt
434	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.503	0.193	0.251	0.75	5.99	2.99	Double	0.249	ST3M 453-4-26 bolt
435	AS1/3501-6	50/40/10	[45/-45/2/90/(0)5]s	1.512	0.195	0.251	0.75	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
436	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.512	0.195	0.249	0.75	6.07	3.01	Double	0.249	ST3M 453-4-26 bolt
437	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.512	0.195	0.249	0.75	6.07	3.01	Double	0.249	ST3M 453-4-26 bolt
438	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.512	0.195	0.249	0.75	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
439	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.198	0.249	0.75	6.04	3.01	Double	0.249	ST3M 453-4-26 bolt
440	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.198	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
441	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.502	0.191	0.250	0.75	6.01	3.00	Double	0.249	ST3M 453-4-26 bolt
442	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.502	0.195	0.253	0.75	6.01	3.00	Double	0.249	ST3M 453-4-26 bolt
443	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.2142	0.251	0.75	6.00	2.99	Double	0.249	ST3M 453-4-26 bolt
444	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.2142	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
445	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.2142	0.250	0.75	6.05	3.01	Double	0.249	ST3M 453-4-26 bolt
446	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.2142	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
447	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.507	0.2154	0.249	0.75	6.05	3.01	Double	0.249	ST3M 453-4-26 bolt
448	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.503	0.2141	0.250	0.75	6.01	3.00	Double	0.249	ST3M 453-4-26 bolt
449	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.2013	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
450	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.201	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
451	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.224	0.250	0.75	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
452	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.490	0.2155	0.250	0.75	5.96	3.00	Single	0.249	ST3M 453-4-18 bolt
453	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.503	0.2163	0.250	0.75	6.01	3.00	Single	0.249	ST3M 453-4-18 bolt
454	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.503	0.2208	0.249	0.75	6.04	3.01	Single	0.249	ST3M 453-4-18 bolt
455	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.2115	0.251	0.50	5.99	1.99	Single	0.249	ST3M 453-4-18 bolt
456	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.2221	0.251	0.50	5.99	1.99	Single	0.249	ST3M 453-4-18 bolt
457	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.501	0.211	0.250	0.50	6.00	2.00	Single	0.249	ST3M 453-4-18 bolt
458	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.504	0.1975	0.252	0.50	5.97	1.98	Single	0.249	ST3M 453-4-18 bolt
459	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.1947	0.253	0.50	5.95	1.98	Single	0.249	ST3M 453-4-18 bolt
460	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.509	0.1947	0.250	0.50	6.02	2.00	Single	0.249	ST3M 453-4-18 bolt
461	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.1947	0.249	0.50	6.05	2.01	Single	0.249	ST3M 453-4-18 bolt
462	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.506	0.1947	0.250	0.50	6.02	2.00	Single	0.249	ST3M 453-4-18 bolt
463	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.2073	0.250	0.75	6.02	3.00	Single	0.249	ST3M 453-4-18 bolt
464	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.2073	0.249	0.75	6.04	3.01	Single	0.249	ST3M 453-4-18 bolt
465	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.2073	0.250	0.75	6.02	3.00	Single	0.249	ST3M 453-4-18 bolt
466	AS1/3501-6	50/40/10	[45/-45/2/90/0/45/-45/0/2]s	1.505	0.2073	0.249	0.75	6.04	3.01	Single	0.249	ST3M 453-4-18 bolt
467	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.004	0.2101	0.250	0.75	4.02	3.00	Single	0.249	ST3M 453-4-18 bolt
468	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.004	0.2101	0.249	0.75	4.03	3.01	Single	0.249	ST3M 453-4-18 bolt
469	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.004	0.2101	0.250	0.75	4.02	3.00	Single	0.249	ST3M 453-4-18 bolt
470	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	1.004	0.2101	0.249	0.75	4.03	3.01	Single	0.249	ST3M 453-4-18 bolt

## Single J-Tension

	M	N	Q	P	Q	R	S	T	U	V	W	X	Y	Z
424	50	250 F	0.77	2850	Unknown	59	Unknown	9.8	9.8	845 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
425	50	250 F	0.81	4100	Unknown	82	Unknown	13.6	13.6	1263 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
426	50	250 F	0.82	4540	Unknown	90	Unknown	14.8	14.8	1385 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
427	50	RT	0.00	4720	Unknown	99	Unknown	16.5	16.6	1325 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
428	50	RT	0.00	4200	Unknown	89	Unknown	14.7	14.8	1165 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
429	50	RT	0.00	4200	Unknown	89	Unknown	14.7	14.8	1260 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
430	50	RT	0.00	4360	Unknown	92	Unknown	15.3	15.4	1410 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
431	50	250 F	0.68	3500	Unknown	77	Unknown	12.7	12.8	1030 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
432	50	250 F	0.75	3400	Unknown	73	Unknown	12.1	12.2	1030 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
433	50	250 F	0.78	3230	Unknown	67	Unknown	11.1	11.2	1165 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
434	50	250 F	0.78	3660	Unknown	76	Unknown	12.6	12.6	1160 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
435	50	RT	0.00	6520	Unknown	133	Unknown	22.1	22.3	1895 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
436	50	RT	0.00	7120	Unknown	147	Unknown	24.1	24.3	2105 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
437	50	RT	0.00	7180	Unknown	148	Unknown	24.4	24.5	2170 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
438	50	RT	0.00	7280	Unknown	149	Unknown	24.7	24.9	2295 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
439	50	250 F	0.74	5700	Unknown	116	Unknown	19.1	19.2	1610 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
440	50	250 F	0.74	5200	Unknown	105	Unknown	17.5	17.5	1560 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
441	50	250 F	0.66	5040	Unknown	108	Unknown	17.6	17.6	1520 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
442	50	250 F	0.73	4380	Unknown	90	Unknown	15.0	15.0	1235 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
443	50	RT	0.00	8330	Unknown	118	Unknown	19.6	19.7	1845 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
444	50	RT	0.00	6450	Unknown	120	Unknown	20.0	20.1	1940 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
445	50	RT	0.00	6400	Unknown	120	Unknown	19.8	19.9	1935 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
446	50	RT	0.00	6390	Unknown	119	Unknown	19.8	19.9	1965 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
447	50	250 F	0.87	4680	Unknown	87	Unknown	14.4	14.5	1235 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
448	50	250 F	0.87	4500	Unknown	84	Unknown	14.0	14.0	1350 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
449	50	250 F	0.80	3720	Unknown	74	Unknown	12.3	12.3	1150 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
450	50	250 F	0.80	3840	Unknown	76	Unknown	12.7	12.7	1120 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
451	50	250 F	0.93	4820	Unknown	83	Unknown	13.7	13.8	1080 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
452	50	250 F	0.83	5380	Unknown	100	Unknown	16.6	16.6	1680 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
453	50	250 F	0.88	4820	Unknown	89	Unknown	14.8	14.9	1420 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
454	50	250 F	0.89	5700	Unknown	104	Unknown	17.2	17.2	1670 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
455	50	250 F	0.82	3420	Unknown	64	Unknown	10.8	16.2	1045 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
456	50	250 F	0.92	3885	Unknown	70	Unknown	11.6	17.5	1225 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
457	50	250 F	0.85	3930	Unknown	75	Unknown	12.4	18.6	1090 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
458	50	250 F	0.76	3900	Unknown	78	Unknown	13.1	19.7	1140 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
459	50	RT	0.00	3440	Unknown	70	Unknown	11.7	17.7	1030 Sher	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
460	50	RT	0.00	4270	Unknown	88	Unknown	14.6	21.9	1310 Sher	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
461	50	RT	0.00	4430	Unknown	91	Unknown	15.1	22.8	1395 Sher	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
462	50	RT	0.00	4250	Unknown	87	Unknown	14.5	21.8	1350 Sher	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
463	50	RT	0.00	7770	Unknown	150	Unknown	24.9	25.0	2220 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
464	50	RT	0.00	6390	Unknown	124	Unknown	20.5	20.5	1820 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
465	50	RT	0.00	7160	Unknown	138	Unknown	22.9	23.0	2060 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
466	50	RT	0.00	6040	Unknown	117	Unknown	19.4	19.4	1770 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
467	50	RT	0.00	6740	Unknown	128	Unknown	32.0	21.4	2795 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
468	50	RT	0.00	6240	Unknown	119	Unknown	29.6	19.8	2580 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
469	50	RT	0.00	6220	Unknown	118	Unknown	29.5	19.7	2670 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep
470	50	RT	0.00	5660	Unknown	112	Unknown	27.8	18.6	2485 Sh & Br	Unknown	Unknown	Garbo et al [1-38]	Gr/Ep

### Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
471	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.253	0.1993	0.378	1.125	5.96	2.98	Single	0.249	ST3M 453-6-18 bolt
472	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.253	0.1993	0.375	1.125	6.01	3.00	Single	0.249	ST3M 453-6-18 bolt
473	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.253	0.1993	0.375	1.125	6.01	3.00	Single	0.249	ST3M 453-6-18 bolt
474	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.250	0.1896	0.375	1.125	6.03	3.00	Single	0.249	ST3M 453-6-18 bolt
475	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.4503	0.380	1.125	5.94	2.96	Double	0.249	ST3M 453-6-18 bolt
476	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.4503	0.375	1.125	6.02	3.00	Double	0.249	ST3M 453-6-40 bolt
477	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.4503	0.375	1.125	6.02	3.00	Double	0.249	ST3M 453-6-40 bolt
478	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.4503	0.375	1.125	6.02	3.00	Double	0.249	ST3M 453-6-40 bolt
479	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.255	0.4485	0.385	1.125	5.86	2.92	Double	0.249	ST3M 453-6-40 bolt
480	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.4635	0.380	1.125	5.94	2.96	Double	0.249	ST3M 453-6-40 bolt
481	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.249	0.4491	0.375	1.125	6.00	3.00	Double	0.249	ST3M 453-6-40 bolt
482	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.259	0.4493	0.378	1.125	6.01	2.99	Double	0.249	ST3M 453-6-40 bolt
483	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.254	0.6511	0.378	1.125	5.95	2.97	Double	0.249	ST3M 453-6-52 bolt
484	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.254	0.6511	0.375	1.125	6.01	3.00	Double	0.249	ST3M 453-6-52 bolt
485	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.254	0.6511	0.375	1.125	6.01	3.00	Double	0.249	ST3M 453-6-52 bolt
486	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.254	0.6511	0.375	1.125	6.01	3.00	Double	0.249	ST3M 453-6-52 bolt
487	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.254	0.6511	0.375	1.125	6.01	3.00	Double	0.249	ST3M 453-6-52 bolt
488	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.253	0.8617	0.562	1.125	4.01	2.00	Double	0.249	ST3M 453-9-52 bolt
489	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.260	0.8698	0.562	1.125	4.02	2.00	Double	0.249	ST3M 453-9-52 bolt
490	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.8767	0.562	1.125	4.01	2.00	Double	0.249	ST3M 453-9-52 bolt
491	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.256	0.8711	0.562	1.125	4.01	2.00	Double	0.249	ST3M 453-9-52 bolt
492	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.250	0.2140	0.563	1.125	4.00	2.00	Double	0.249	ST3M 453-9-52 bolt
493	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.250	0.2140	0.578	1.125	4.00	2.00	Double	0.249	ST3M 453-9-52 bolt
494	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.250	0.2140	0.375	1.125	6.00	3.00	Double	0.249	ST3M 453-6-24 bolt
495	AS1/3501-6	50/40/10	[45/0/-45/0/90/0/45/0/-45/0]s	2.25								

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
471	50 RT	0.00	9140	Unknown	121	Unknown	20.4	20.4	20.4	1715	Sh & Br	Unknown	Garbo et al [1-38]	
472	50 RT	0.00	9200	Unknown	123	Unknown	20.5	20.5	20.5	1815	Bear	Unknown	Garbo et al [1-38]	
473	50 RT	0.00	8600	Unknown	115	Unknown	19.2	19.2	19.2	1735	Sh & Br	Unknown	Garbo et al [1-38]	
474	50 RT	0.00	7230	Unknown	102	Unknown	16.9	16.9	16.9	1535	Bear	Unknown	Garbo et al [1-38]	
475	160 RT	0.00	8575	Unknown	121	Unknown	20.0	20.0	20.1	1730	Sh & Br	Unknown	Garbo et al [1-38]	
476	50 RT	0.00	21900	Unknown	128	Unknown	21.6	21.6	21.6	1960	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
477	50 RT	0.00	21400	Unknown	127	Unknown	21.1	21.1	21.1	1935	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
478	50 RT	0.00	21300	Unknown	126	Unknown	21.0	21.0	21.0	1915	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
479	50 RT	0.00	21500	Unknown	127	Unknown	21.2	21.2	21.2	1950	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
480	160 250 F	1.15	18600	Unknown	108	Unknown	18.4	18.4	18.4	1965	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
481	160 250 F	1.15	18900	Unknown	107	Unknown	18.1	18.1	18.1	1735	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
482	160 250 F	1.17	17200	Unknown	102	Unknown	16.9	16.9	17.0	1830	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
483	160 250 F	1.17	17200	Unknown	131	Unknown	22.0	22.0	22.0	2000	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
484	50 RT	0.00	32300	Unknown	127	Unknown	21.1	21.1	21.1	1920	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
485	50 RT	0.00	30900	Unknown	131	Unknown	21.9	21.9	21.9	1985	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
486	50 RT	0.00	32100	Unknown	126	Unknown	20.9	21.0	21.0	1865	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
487	50 RT	0.00	30700	Unknown	85	Unknown	21.2	21.2	21.2	2330	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
488	160 250 F	0.88	32500	Unknown	89	Unknown	22.1	22.2	22.2	2260	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
489	160 250 F	0.88	34800	Unknown	91	Unknown	22.7	22.7	22.7	2260	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
490	160 250 F	0.88	34000	Unknown	89	Unknown	22.1	22.1	22.1	2185	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
491	160 250 F	0.86	33400	Unknown	83	Unknown	20.7	20.7	20.7	1915	Shear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp
492	50 RT	0.00	9990	Unknown	114	Unknown	19.2	19.2	19.2	1815	Shear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
493	50 RT	0.00	9240	Unknown	107	Unknown	17.9	17.9	17.9	1690	Shear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
494	160 RT	0.00	8620	Unknown	123	Unknown	20.5	20.5	20.5	1480	Shear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
495	160 RT	0.00	9850	Unknown	137	Unknown	22.9	22.9	22.9	2200	Sh & Br	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
496	50 RT	0.00	20300	Unknown	121	Unknown	20.2	20.2	20.2	1960	Sh & Br	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
497	50 RT	0.00	18900	Unknown	112	Unknown	18.6	18.6	18.6	1800	Sh & Br	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
498	50 RT	0.00	23300	Unknown	137	Unknown	22.9	22.9	22.9	2175	Sh & Br	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
499	50 RT	0.00	13900	Unknown	179	Unknown	30.0	30.0	30.0	1310	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
500	50 RT	0.00	13900	Unknown	180	Unknown	30.0	30.0	30.0	1180	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
501	50 RT	0.00	14800	Unknown	192	Unknown	31.9	31.9	31.9	1315	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
502	50 RT	0.00	15000	Unknown	194	Unknown	32.3	32.3	32.4	1450	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
503	50 RT	0.00	14800	Unknown	192	Unknown	31.9	31.9	31.9	1430	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
504	50 RT	0.00	15000	Unknown	194	Unknown	32.3	32.3	32.4	1470	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
505	50 RT	0.00	15000	Unknown	207	Unknown	34.4	34.4	34.5	1630	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
506	160 RT	0.00	15975	Unknown	207	Unknown	34.4	34.4	34.5	1480	Bear	Unknown	Garbo et al [1-38]	Ti 100 Csk x 0.756 OD, Bushing
507	160 RT	0.00	15975	Unknown	137	Unknown	22.8	22.8	22.8	2190	Ten-clev	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
508	50 RT	0.00	33400	Unknown	138	Unknown	23.0	23.0	23.0	2295	Ten-clev	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
509	50 RT	0.00	33700	Unknown	142	Unknown	23.5	23.5	23.6	2225	Ten-clev	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
510	50 RT	0.00	34500	Unknown	121	Unknown	20.5	20.5	20.6	1970	Shear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
511	50 RT	0.00	30100	Unknown	199	Unknown	33.2	33.2	33.2	1300	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
512	50 RT	0.00	15500	Unknown	199	Unknown	33.2	33.2	33.2	1490	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
513	50 RT	0.00	14600	Unknown	188	Unknown	31.3	31.3	31.3	1380	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
514	50 RT	0.00	14600	Unknown	188	Unknown	31.3	31.3	31.3	1350	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
515	50 RT	0.00	15200	Unknown	195	Unknown	32.5	32.5	32.6	1400	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
516	50 RT	0.00	15200	Unknown	195	Unknown	32.5	32.5	32.6	1500	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing
517	50 RT	0.00	15200	Unknown	195	Unknown	32.5	32.5	32.6	1500	Bear	Unknown	Garbo et al [1-38]	100 Csk x 0.756 OD, Bushing

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
518	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	2.252	0.2074	0.375	1.125	6.01	3.00	Double	0.249	ST3M 430Y6-20 AS bolt
519	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	2.252	0.2074	0.251	1.125	8.97	4.48	Double	0.249	ST3M 430Y6-20 AS bolt
520	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2095	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
521	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2095	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
522	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2095	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
523	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2095	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
524	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.2138	0.250	0.750	6.01	3.00	Double	0.249	ST3M 453-4-26 bolt
525	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2237	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
526	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2109	0.251	0.750	6.00	2.99	Double	0.249	ST3M 453-4-26 bolt
527	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.508	0.2245	0.251	0.750	6.01	2.99	Double	0.249	ST3M 453-4-26 bolt
528	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2194	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
529	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2233	0.252	0.750	5.98	2.98	Double	0.249	ST3M 453-4-26 bolt
530	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.508	0.2121	0.250	0.750	6.03	3.00	Double	0.249	ST3M 453-4-26 bolt
531	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.505	0.2105	0.251	0.750	6.00	2.99	Double	0.249	ST3M 453-4-26 bolt
532	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.203	0.251	0.750	5.99	2.99	Double	0.249	ST3M 453-4-26 bolt
533	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.203	0.251	0.750	5.99	2.99	Double	0.249	ST3M 453-4-26 bolt
534	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.203	0.250	0.750	6.01	3.00	Double	0.249	ST3M 453-4-26 bolt
535	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.203	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
536	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.2103	0.251	0.750	5.99	2.98	Double	0.249	ST3M 453-4-26 bolt
537	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.503	0.2213	0.252	0.750	5.97	2.98	Double	0.249	ST3M 453-4-26 bolt
538	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.501	0.2119	0.251	0.750	5.98	2.99	Double	0.249	ST3M 453-4-26 bolt
539	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.504	0.2208	0.251	0.750	5.98	2.98	Double	0.249	ST3M 453-4-26 bolt
540	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.512	0.2061	0.251	0.750	6.02	2.99	Double	0.249	ST3M 453-4-26 bolt
541	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.512	0.2061	0.250	0.750	6.06	3.00	Double	0.249	ST3M 453-4-26 bolt
542	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.512	0.2061	0.250	0.750	6.05	3.00	Double	0.249	ST3M 453-4-26 bolt
543	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.512	0.2061	0.250	0.750	6.05	3.00	Double	0.249	ST3M 453-4-26 bolt
544	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.511	0.2041	0.251	0.750	6.01	2.98	Double	0.249	ST3M 453-4-26 bolt
545	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.508	0.2196	0.251	0.750	6.01	2.99	Double	0.249	ST3M 453-4-26 bolt
546	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.507	0.2047	0.253	0.750	5.95	2.98	Double	0.249	ST3M 453-4-26 bolt
547	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.509	0.2188	0.252	0.750	5.99	2.98	Double	0.249	ST3M 453-4-26 bolt
548	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.506	0.2128	0.250	0.750	5.92	3.00	Double	0.249	ST3M 453-4-26 bolt
549	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.508	0.2128	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
550	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.507	0.2081	0.250	0.750	6.03	3.00	Double	0.249	ST3M 453-4-26 bolt
551	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.507	0.2081	0.250	0.750	6.04	3.00	Double	0.249	ST3M 453-4-26 bolt
552	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.500	0.2035	0.252	0.750	5.96	2.98	Double	0.249	ST3M 453-4-26 bolt
553	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.500	0.2035	0.251	0.750	5.98	2.98	Double	0.249	ST3M 453-4-26 bolt
554	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.500	0.1999	0.251	0.750	5.97	2.98	Double	0.249	ST3M 453-4-26 bolt
555	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	1.500	0.1999	0.251	0.750	5.98	2.99	Double	0.249	ST3M 453-4-26 bolt
556	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.509	0.2031	0.249	0.750	6.06	3.01	Double	0.249	ST3M 453-4-26 bolt
557	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.502	0.1991	0.249	0.750	6.03	3.01	Double	0.249	ST3M 453-4-26 bolt
558	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.502	0.2013	0.249	0.750	6.03	3.01	Double	0.249	ST3M 453-4-26 bolt
559	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.507	0.2035	0.249	0.750	6.05	3.01	Double	0.249	ST3M 453-4-26 bolt
560	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.505	0.1972	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
561	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.509	0.207	0.249	0.750	6.06	3.01	Double	0.249	ST3M 453-4-26 bolt
562	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.506	0.2007	0.250	0.750	6.02	3.00	Double	0.249	ST3M 453-4-26 bolt
563	AS1/3501-6	10/40/50	145/90/-45/90/0/90/45/90/-45/90/s	1.506	0.1977	0.249	0.750	6.05	3.01	Double	0.249	ST3M 453-4-26 bolt
564	AS1/3501-6	50/40/10	145/0/-45/0/90/0/45/0/-45/0/s	2.254	0.2092	0.375	1.125	6.01	3.00	Double	0.375	ST3M 453-6-34 bolt

## Single J-Tension

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
518	50 RT		0.00	15450	Unknown	199	Unknown	33.1	33.1	1330	Bear	Unknown	Garbo et al [1-38]	Al 100 Csk x 0.756 OD, Bushing
519	160 RT		0.00	15450	Unknown	297	Unknown	33.1	33.1	1730	Bear	Unknown	Garbo et al [1-38]	Al 100 Csk x 0.756 OD, Bushing
520	160 RT		0.00	7420	Unknown	142	Unknown	23.6	23.6	2115	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
521	50 RT		0.00	7610	Unknown	145	Unknown	24.1	24.2	2220	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
522	50 RT		0.00	7550	Unknown	144	Unknown	23.9	24.0	2180	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
523	50 RT		0.00	7220	Unknown	138	Unknown	22.9	23.0	2200	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
524	50 RT		0.90	7580	Unknown	142	Unknown	23.6	23.6	2345	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
525	50 RT		0.88	7500	Unknown	134	Unknown	22.3	22.4	2260	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
526	50 RT		0.77	7720	Unknown	146	Unknown	24.3	24.4	2280	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
527	50 RT		0.88	7820	Unknown	139	Unknown	23.1	23.2	2360	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
528	50 250 F		0.89	5500	Unknown	100	Unknown	16.6	16.7	1490	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
529	50 250 F		0.90	5780	Unknown	103	Unknown	17.2	17.3	1785	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
530	50 250 F		0.81	5020	Unknown	95	Unknown	15.7	15.8	1410	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
531	50 250 F		0.81	5030	Unknown	95	Unknown	15.9	15.9	1510	Sh & Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 10 off a
532	50 RT		0.00	7700	Unknown	151	Unknown	25.2	25.3	2690	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
533	50 RT		0.00	7770	Unknown	153	Unknown	25.5	25.5	2760	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
534	50 RT		0.00	7640	Unknown	151	Unknown	25.0	25.1	2750	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
535	50 RT		0.00	7680	Unknown	151	Unknown	25.1	25.2	2795	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
536	50 250 F		0.81	5950	Unknown	113	Unknown	18.8	18.9	2195	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
537	50 250 F		0.87	6200	Unknown	111	Unknown	18.6	18.7	2270	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
538	50 250 F		0.80	5220	Unknown	98	Unknown	16.4	16.4	1930	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
539	50 250 F		0.87	5090	Unknown	92	Unknown	15.3	15.4	1910	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 22.5 off
540	50 RT		0.00	7430	Unknown	144	Unknown	23.8	24.0	3600	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
541	50 RT		0.00	7380	Unknown	143	Unknown	23.7	23.9	3740	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
542	50 RT		0.00	7600	Unknown	147	Unknown	24.4	24.6	3930	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
543	50 RT		0.00	7650	Unknown	148	Unknown	24.5	24.7	4000	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
544	50 250 F		0.76	6080	Unknown	118	Unknown	19.7	19.9	2105	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
545	50 250 F		0.87	5960	Unknown	108	Unknown	18.0	18.1	3095	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
546	50 250 F		0.81	5280	Unknown	102	Unknown	17.1	17.2	2910	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 45 off a
547	50 250 F		0.88	4720	Unknown	86	Unknown	14.3	14.4	2580	S,B,T-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 67.5 off
548	50 RT		0.00	7840	Unknown	147	Unknown	24.5	24.6	4995	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 67.5 off
549	50 RT		0.00	7420	Unknown	139	Unknown	23.2	23.2	4800	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 67.5 off
550	50 RT		0.00	7450	Unknown	143	Unknown	23.8	23.9	4920	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 67.5 off
551	50 RT		0.00	7270	Unknown	146	Unknown	23.2	23.3	4700	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 80 off a
552	50 RT		0.00	7370	Unknown	144	Unknown	24.1	24.1	4870	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 80 off a
553	50 RT		0.00	7550	Unknown	148	Unknown	24.7	24.7	5025	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 80 off a
554	50 RT		0.00	6750	Unknown	134	Unknown	22.5	22.5	4395	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 80 off a
555	50 RT		0.00	7330	Unknown	146	Unknown	24.4	24.4	4840	Sh, Te-Br	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 80 off a
556	50 RT		0.00	6240	Unknown	123	Unknown	20.4	20.5	2270	Tens	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
557	50 RT		0.00	6360	Unknown	128	Unknown	21.3	21.3	2270	Tens	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
558	50 RT		0.00	6580	Unknown	131	Unknown	21.8	21.8	2340	Tens	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
559	50 RT		0.00	6810	Unknown	134	Unknown	22.2	22.3	2410	Tens	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
560	50 250 F		0.79	4820	Unknown	98	Unknown	16.2	16.3	3780	Be & Te	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
561	50 250 F		0.78	5400	Unknown	105	Unknown	17.3	17.4	3905	Bear	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
562	50 250 F		0.78	4320	Unknown	86	Unknown	14.3	14.3	3490	Be & Te	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
563	50 250 F		0.78	4570	Unknown	93	Unknown	15.3	15.4	3800	Be & Te	Unknown	Garbo et al [1-38]	Bushing bel. bo-sp, 90 off a
564	10 + Gap RT		0.00	7380	Unknown	94	Unknown	15.7	15.7	1460	Bear	Unknown	Garbo et al [1-38]	13/16 IDx1/4 OD Fl washer,Bus

	A	B	C	D	E	F	G	H	I	J	K	L
565	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2184	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
566	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2212	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
567	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2274	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
568	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2258	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
569	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,253	0,2288	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
570	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2149	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
571	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,253	0,2058	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
572	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2278	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
573	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2259	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
574	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,254	0,2270	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
575	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,253	0,2297	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
576	AS1/3501-6	30/60/10	45/0/-45/0/45/80/-45/0/45/-45/5	2,253	0,2250	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
577	AS1/3501-6	30/60/10	45/0/-45/0/45/80/-45/0/45/-45/5	2,253	0,2278	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
578	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/-45/5	2,251	0,2448	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
579	AS1/3501-6	19/76/5	45/0/-45/0/45/330/45/45/330/45/0/45/5	2,251	0,2381	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
580	AS1/3501-6	19/76/5	45/0/-45/0/45/330/45/45/330/45/0/45/5	2,250	0,2300	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
581	AS1/3501-6	19/76/5	45/0/-45/0/45/330/45/45/330/45/0/45/5	2,253	0,2313	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
582	AS1/3501-6	50/40/10	45/0/0/2/90/0/1/45/0/2/5	2,253	0,2227	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
583	AS1/3501-6	50/40/10	45/0/0/2/90/0/1/45/0/2/5	2,253	0,2289	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
584	AS1/3501-6	50/40/10	45/0/0/2/90/0/1/45/0/2/5	2,251	0,2462	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
585	AS1/3501-6	19/76/5	45/0/0/2/45/290/0/45/45/2/45/45/2	2,250	0,2365	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
586	AS1/3501-6	19/76/5	45/0/0/2/45/290/0/45/45/2/45/45/2	2,249	0,2438	0,375	1,125	6,00	3,00	Double	0,375	ST3M 453-6-34 bolt
587	AS1/3501-6	19/76/5	45/0/0/2/45/290/0/45/45/2/45/45/2	2,254	0,2205	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
588	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/5	2,255	0,2299	0,375	1,125	6,01	3,00	Double	0,375	ST3M 453-6-34 bolt
589	AS1/3501-6	50/										

M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
565	0 + Gap RT	0.00	7500	Unknown	92	Unknown	15.2	15.3	1352	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
566	0 + Gap RT	0.00	7720	Unknown	93	Unknown	15.5	15.5	1390	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
567	0 + Gap RT	0.85	7150	Unknown	84	Unknown	13.9	14.0	1458	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
568	0 + Gap RT	0.82	7300	Unknown	86	Unknown	14.3	14.4	1410	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
569	0 + Gap RT	0.82	7300	Unknown	85	Unknown	14.1	14.1	1420	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
570	0 + Gap 250 F	0.78	4820	Unknown	60	Unknown	9.9	10.0	858	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
571	0 + Gap 250 F	0.71	3475	Unknown	45	Unknown	7.5	7.5	660	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
572	0 + Gap 250 F	0.82	4340	Unknown	51	Unknown	8.5	8.5	840	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
573	0 + Gap RT	0.89	7000	Unknown	83	Unknown	13.8	13.8	1400	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
574	0 + Gap RT	0.91	7130	Unknown	84	Unknown	14.0	14.0	1380	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
575	0 + Gap RT	0.86	6940	Unknown	82	Unknown	13.6	13.6	1380	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
576	0 + Gap RT	0.00	7500	Unknown	87	Unknown	14.5	14.5	1925	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
577	0 + Gap RT	0.00	7500	Unknown	89	Unknown	14.8	14.8	1900	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
578	0 + Gap RT	0.00	7430	Unknown	87	Unknown	14.5	14.5	1900	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
579	0 + Gap RT	0.00	8050	Unknown	88	Unknown	14.6	14.6	2670	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
580	0 + Gap RT	0.00	7750	Unknown	87	Unknown	14.5	14.5	2665	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
581	0 + Gap RT	0.00	7750	Unknown	90	Unknown	15.0	15.0	2600	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
582	0 + Gap RT	0.00	6850	Unknown	79	Unknown	13.1	13.2	1235	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
583	0 + Gap RT	0.00	7500	Unknown	90	Unknown	14.9	15.0	1365	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
584	0 + Gap RT	0.00	7350	Unknown	86	Unknown	14.3	14.3	1400	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
585	0 + Gap RT	0.00	8000	Unknown	87	Unknown	14.4	14.4	2665	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
586	0 + Gap RT	0.00	7800	Unknown	88	Unknown	14.7	14.7	2575	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
587	0 + Gap RT	0.00	8400	Unknown	92	Unknown	15.3	15.3	2915	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
588	150 RT	0.00	9060	Unknown	110	Unknown	18.2	18.3	1835	Shear	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
589	150 RT	0.00	9690	Unknown	112	Unknown	18.7	18.7	1795	Ten-clev	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
590	160 RT	0.00	9300	Unknown	108	Unknown	18.0	18.0	1755	Shear	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
591	160 RT	0.00	12530	Unknown	144	Unknown	24.0	24.0	4400	Tens	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
592	160 RT	0.00	12840	Unknown	138	Unknown	23.0	23.0	4205	Ten-clev	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
593	160 RT	0.00	12530	Unknown	138	Unknown	23.0	23.0	4145	Ten-clev	Unknown	Carbo et al (1-38)	Bushing bo-sp for load block
594	0 + Gap RT	0.00	7620	Unknown	88	Unknown	21.9	14.6	2040	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
595	0 + Gap RT	0.00	7080	Unknown	88	Unknown	21.9	14.7	2035	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
596	0 + Gap RT	0.00	7620	Unknown	92	Unknown	22.9	15.3	2555	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
597	0 + Gap RT	0.00	7470	Unknown	87	Unknown	21.7	10.9	2095	Ten-clev	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
598	0 + Gap RT	0.00	7620	Unknown	91	Unknown	22.6	11.4	2165	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
599	0 + Gap RT	0.00	7740	Unknown	95	Unknown	23.7	11.9	2210	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
600	0 + Gap RT	0.00	9225	Unknown	100	Unknown	25.1	16.7	4800	Tens	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
601	0 + Gap RT	0.00	7275	Unknown	82	Unknown	20.5	13.6	3400	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
602	0 + Gap RT	0.00	7450	Unknown	81	Unknown	20.2	13.4	3610	Bear	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
603	0 + Gap RT	0.00	6420	Unknown	70	Unknown	23.4	11.7	4005	Tens	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
604	0 + Gap RT	0.00	6280	Unknown	68	Unknown	22.6	11.3	3805	Tens	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
605	0 + Gap RT	0.00	8360	Unknown	70	Unknown	23.3	11.6	3890	Tens	Unknown	Carbo et al (1-38)	13/16 IDx1/4 OD Fl washer,Bus
606	0 + Gap RT	0.00	8100	Unknown	97	Unknown	15.8	15.8	1730	Shear	Unknown	Carbo et al (1-38)	Bushing pin-sp for load block
607	0 + Gap RT	0.00	7350	Unknown	94	Unknown	15.4	15.4	1548	Ten-clev	Unknown	Carbo et al (1-38)	Bushing pin-sp for load block
608	0 + Gap RT	0.00	8850	Unknown	105	Unknown	17.2	17.3	1450	Shear	Unknown	Carbo et al (1-38)	Bushing pin-sp for load block
609	160 RT	0.00	8950	Unknown	115	Unknown	19.1	19.1	1770	Ten-clev	Unknown	Carbo et al (1-38)	Protruding bolt head
610	160 RT	0.00	9100	Unknown	105	Unknown	17.5	17.5	1830	Shear	Unknown	Carbo et al (1-38)	Protruding bolt head
611	160 RT	0.00	9700	Unknown	113	Unknown	18.7	18.8	1690	Bear	Unknown	Carbo et al (1-38)	Protruding bolt head

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
612	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/-45/0/s	2.253	0.2294	0.375	1.125	6.01	3.00	Single	0.375	ST3M 430V6-18AS bolt
613	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/s	2.254	0.2238	0.375	1.125	6.01	3.00	Single	0.375	ST3M 430V6-18AS bolt
614	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/s	2.254	0.2148	0.375	1.125	6.01	3.00	Single	0.375	ST3M 430V6-18AS bolt
615	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/s	2.250	0.2254	0.376	1.125	5.98	2.99	Double	0.375	ST3M 453-6-34 bolt
616	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/s	2.250	0.2321	0.376	1.125	5.98	2.99	Double	0.375	ST3M 453-6-34 bolt
617	AS1/3501-6	50/40/10	[(45/0/-45/0/90/0/45/0/-45/0/s	2.250	0.2271	0.375	1.125	6.00	3.00	Double	0.375	ST3M 453-6-34 bolt
618	AS4/3501-6	49/39/12	Unknown	0.998	0.213	0.250	0.75	3.99	3.00	Single	0.250	Ti Csk tension-head
619	AS4/3501-6	49/39/12	Unknown	1.000	0.260	0.250	0.75	4.00	3.00	Single	0.250	Ti Csk tension-head
620	AS4/3501-6	49/39/12	Unknown	0.999	0.213	0.250	0.75	4.00	3.00	Single	0.250	St Csk tension-head
621	AS4/3501-6	49/39/12	Unknown	1.001	0.280	0.250	0.75	4.00	3.00	Single	0.250	St Csk tension-head
622	AS4/3501-6	49/39/12	Unknown	1.250	0.213	0.313	0.939	3.99	3.00	Single	0.312	Ti Csk tension-head
623	AS4/3501-6	49/39/12	Unknown	1.251	0.260	0.313	0.939	4.00	3.00	Single	0.312	Ti Csk tension-head
624	AS4/3501-6	49/39/12	Unknown	1.249	0.213	0.313	0.939	3.99	3.00	Single	0.312	St Csk tension-head
625	AS4/3501-6	49/39/12	Unknown	1.250	0.260	0.313	0.939	3.99	3.00	Single	0.312	St Csk tension-head
626	AS4/3501-6	60/30/10	Unknown	1.001	0.213	0.250	0.75	4.00	3.00	Single	0.250	Ti Csk tension-head
627	AS4/3501-6	60/30/10	Unknown	0.999	0.280	0.250	0.75	4.00	3.00	Single	0.250	Ti Csk tension-head
628	AS4/3501-6	60/30/10	Unknown	1.001	0.213	0.250	0.75	4.00	3.00	Single	0.250	St Csk tension-head
629	AS4/3501-6	60/30/10	Unknown	0.999	0.260	0.250	0.75	4.00	3.00	Single	0.250	St Csk tension-head
630	AS4/3501-6	60/30/10	Unknown	1.249	0.213	0.313	0.939	3.99	3.00	Single	0.312	Ti Csk tension-head
631	AS4/3501-6	60/30/10	Unknown	1.250	0.260	0.313	0.939	3.99	3.00	Single	0.312	Ti Csk tension-head
632	AS4/3501-6	60/30/10	Unknown	1.250	0.213	0.313	0.939	3.99	3.00	Single	0.312	St Csk tension-head
633	AS4/3501-6	60/30/10	Unknown	1.250	0.260	0.313	0.939	3.99	3.00	Single	0.312	St Csk tension-head
634	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.501	0.119	0.249	0.754	6.03	3.03	Single	0.250	St Pr. head 51B464-4A8
635	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.501	0.119	0.250	0.758	6.00	3.03	Single	0.250	St Pr. head 51B464-4A8
636	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.501	0.118	0.249	0.741	6.03	2.98	Single	0.250	St Pr. head 51B464-4A8
637	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.875	0.121	0.311	0.937	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
638	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.120	0.314	0.937	5.98	2.98	Single	0.313	St Pr. head 51B464-5A8
639	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.119	0.314	0.939	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
640	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	3.000	0.120	0.500	1.500	6.00	3.00	Single	0.500	St Pr. head 51B464-5A8
641	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	3.000	0.117	0.500	1.471	6.00	2.94	Single	0.500	St Pr. head 51B464-5A8
642	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	3.000	0.120	0.500	1.501	6.00	3.00	Single	0.500	St Pr. head 51B464-5A8
643	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	4.502	0.119	0.750	2.258	6.00	3.01	Single	0.750	St Pr. head 51B464-5A8
644	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	4.502	0.121	0.750	2.249	6.00	3.00	Single	0.750	St Pr. head 51B464-5A8
645	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	4.502	0.119	0.750	2.251	6.00	3.00	Single	0.750	St Pr. head 51B464-5A8
646	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.121	0.311	0.470	6.03	1.51	Single	0.313	St Pr. head 51B464-5A8
647	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.115	0.314	0.470	5.97	1.50	Single	0.313	St Pr. head 51B464-5A8
648	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.875	0.121	0.311	0.702	6.03	2.26	Single	0.313	St Pr. head 51B464-5A8
649	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.119	0.314	0.708	5.97	2.25	Single	0.313	St Pr. head 51B464-5A8
650	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.875	0.120	0.314	0.700	5.97	2.23	Single	0.313	St Pr. head 51B464-5A8
651	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.120	0.311	1.247	6.03	4.01	Single	0.313	St Pr. head 51B464-5A8
652	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.120	0.315	1.342	5.96	4.26	Single	0.313	St Pr. head 51B464-5A8
653	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.875	0.120	0.314	1.352	5.97	4.31	Single	0.313	St Pr. head 51B464-5A8
654	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.120	0.311	1.580	6.03	5.02	Single	0.313	St Pr. head 51B464-5A8
655	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.877	0.121	0.314	1.558	5.98	4.96	Single	0.313	St Pr. head 51B464-5A8
656	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90/s	1.876	0.120	0.314	1.584	5.97	4.98	Single	0.313	St Pr. head 51B464-5A8

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
612	160 RT		0.00	8050	Unknown	94	Unknown	15.6	15.6	1395	Sh, Te-cl	Unknown	Garbo et al [1-38]	100 Cskk x 0.756 O.D.
613	160 RT		0.00	8400	Unknown	100	Unknown	16.7	16.7	1500	Sh, Te-cl	Unknown	Garbo et al [1-38]	100 Cskk x 0.756 O.D.
614	160 RT		0.00	8150	Unknown	101	Unknown	16.8	16.9	1455	Shear	Unknown	Garbo et al [1-38]	100 Cskk x 0.756 O.D.
615	0 + Gap RT		0.00	7860	Unknown	93	Unknown	15.5	15.5	1465	Bear	Unknown	Garbo et al [1-38]	13/16 IDx1/4 OD FI washer, Bus
616	0 + Gap RT		0.00	7490	Unknown	85	Unknown	14.3	14.3	1395	Bear	Unknown	Garbo et al [1-38]	13/16 IDx1/4 OD FI washer, Bus
617	0 + Gap RT		0.00	8100	Unknown	95	Unknown	15.9	15.9	1545	Bear	Unknown	Garbo et al [1-38]	13/16 IDx1/4 OD FI washer, Bus
618	95 RT		0.00	4979	Unknown	94	Unknown	23.4	15.6	2139	Unknown	218.5	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
619	95 RT		0.00	5563	Unknown	86	Unknown	21.4	14.3	2275	Unknown	270.2	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
620	95 RT		0.00	6067	Unknown	114	Unknown	28.5	19.0	2122	Unknown	258.9	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
621	95 RT		0.00	8452	Unknown	99	Unknown	24.8	16.5	2234	Unknown	161	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
622	155/80 RT		0.00	6823	Unknown	102	Unknown	25.6	17.1	2122	Unknown	1382.9	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
623	155/80 RT		0.00	8152	Unknown	100	Unknown	25.1	16.7	2320	Unknown	1211.5	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
624	155/80 RT		0.00	7178	Unknown	108	Unknown	27.0	17.9	2142	Unknown	389.9	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
625	155/80 RT		0.00	8732	Unknown	107	Unknown	28.9	17.9	1943	Unknown	398.9	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
626	95 RT		0.00	4941	Unknown	93	Unknown	23.2	15.5	2138	Unknown	152.7	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
627	95 RT		0.00	5522	Unknown	85	Unknown	26.0	14.2	1585	Unknown	280.2	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
628	95 RT		0.00	5537	Unknown	104	Unknown	28.0	17.3	1562	Unknown	288	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
629	95 RT		0.00	6137	Unknown	94	Unknown	23.6	15.7	2034	Unknown	184.9	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
630	155/80 RT		0.00	6527	Unknown	98	Unknown	24.5	16.3	2120	Unknown	567	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
631	155/80 RT		0.00	7601	Unknown	93	Unknown	23.4	15.6	2009	Unknown	433.4	Averill, Zamaai [2-7]	Ti TenS-160 ksi. Data=Avg 3 sp
632	155/80 RT		0.00	8488	Unknown	97	Unknown	24.4	16.2	2335	Unknown	305.4	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
633	155/80 RT		0.00	7769	Unknown	95	Unknown	23.9	15.9	2211	Unknown	328.4	Averill, Zamaai [2-7]	St TenS-220 ksi. Data=Avg 3 sp
634	100 RT		0.00	3936		132.8		22.0	21.9	2139	Ten-clev		Ramkumar...[1-25]	
635	100 RT		0.00	4104	94.12	137.9	15.7	23.0	22.7	2275	Ten-clev	147.0	Ramkumar...[1-25]	
636	100 RT		0.00	3781	74.88	128.7	12.4	21.3	21.6	2122	Clev	145.0	Ramkumar...[1-25]	
637	100 RT		0.00	4856		129.0		21.4	21.4	2234	Sh, Split		Ramkumar...[1-25]	
638	100 RT		0.00	4660	45.12	123.7	7.5	20.7	20.7	2122	Sh, Sp, Del	286.0	Ramkumar...[1-25]	
639	100 RT		0.00	5227	61.55	139.9	10.3	23.4	23.4	2320	Del, Clev	146.0	Ramkumar...[1-25]	
640	100 RT		0.00	6538		108.9		18.2	18.2	2142	Shear		Ramkumar...[1-25]	
641	100 RT		0.00	6216	59.83	108.3	10.0	17.7	18.1	1943	Bear, Spl	280.0	Ramkumar...[1-25]	
642	100 RT		0.00	6595	70.00	109.9	11.7	18.3	18.3	2138	Bear, Del	170.0	Ramkumar...[1-25]	
643	100 RT		0.00	8183	71.59	91.7	11.8	15.3	15.2	2165	Shear, Del		Ramkumar...[1-25]	
644	100 RT		0.00	8537	71.34	94.1	13.2	15.7	15.7	2158	Shear	333.0	Ramkumar...[1-25]	
645	100 RT		0.00	8647	88.14	97.7	14.7	16.3	16.3	2294	Shear, Del	303.0	Ramkumar...[1-25]	
646	100 RT		0.00	3400	31.89	90.4	5.3	15.0	29.9	1585	Shear	163.0	Ramkumar...[1-25]	
647	100 RT		0.00	3527	31.46	97.7	5.1	16.3	32.6	1562	Shear, Del		Ramkumar...[1-25]	
648	100 RT		0.00	4499	30.00	119.6	0.0	19.8	26.5	2034	Del, Clev		Ramkumar...[1-25]	
649	100 RT		0.00	4640	101.05	124.2	17.9	20.8	27.6	2120	Shear, Del	188.0	Ramkumar...[1-25]	
650	100 RT		0.00	4529	111.46	120.2	16.7	20.1	27.0	2009	Shear, Del	194.0	Ramkumar...[1-25]	
651	100 RT		0.00	5037	109.86	135.0	18.2	22.4	16.8	2335	Bear, spl		Ramkumar...[1-25]	
652	100 RT		0.00	4875	95.24	129.0	16.0	22.1	15.1	2211	Bear, spl	194.0	Ramkumar...[1-25]	
653	100 RT		0.00	5188	106.16	137.7	17.8	23.1	16.0	2374	Br, Sp, Del	200.0	Ramkumar...[1-25]	
654	100 RT		0.00	5184	34.83	138.4	5.8	22.9	13.8	2441	Bear, spl		Ramkumar...[1-25]	
655	100 RT		0.00	5056	50.01	133.1	8.4	22.3	13.4	2197	Bear, spl	143.0	Ramkumar...[1-25]	
656	100 RT		0.00	5139	61.04	136.4	10.2	22.8	13.7	2360	Bear, spl	164.0	Ramkumar...[1-25]	

	A	B	C	D	E	F	G	H	I	J	K	L
657	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.121	0.314	0.467	5.97	1.49	Single	0.313	St Pr. head 51B464-5A8
658	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.108	0.314	0.472	5.97	1.50	Single	0.313	St Pr. head 51B464-5A8
659	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.118	0.314	0.472	5.97	1.50	Single	0.313	St Pr. head 51B464-5A8
660	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.122	0.314	1.558	5.97	4.96	Single	0.313	St Pr. head 51B464-5A8
661	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.115	0.314	1.562	5.97	4.97	Single	0.313	St Pr. head 51B464-5A8
662	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.119	0.314	1.559	5.97	4.98	Single	0.313	St Pr. head 51B464-5A8
663	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.121	0.313	0.936	5.99	2.99	Single	0.313	St Csk-T 51B335-9
664	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.120	0.316	0.935	5.94	2.96	Single	0.313	St Csk-T 51B335-9
665	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.118	0.315	0.937	5.96	2.97	Single	0.313	St Csk-T 51B335-9
666	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.122	0.311	0.938	6.03	3.02	Single	0.313	St Csk-S 51B581-5A8
667	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.120	0.315	0.939	5.96	2.98	Single	0.313	St Csk-S 51B581-5A8
668	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.119	0.314	0.940	5.97	2.99	Single	0.313	St Csk-S 51B581-5A8
669	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.119	0.314	0.467	5.97	1.49	Single	0.313	St Pr. head 51B464-5A8
670	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.119	0.314	0.468	5.97	1.49	Single	0.313	St Pr. head 51B464-5A8
671	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.119	0.314	0.470	5.97	1.50	Single	0.313	St Pr. head 51B464-5A8
672	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.120	0.314	1.557	5.97	4.96	Single	0.313	St Pr. head 51B464-5A8
673	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.119	0.314	0.934	5.97	2.97	Single	0.313	St Pr. head 51B464-5A8
674	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.120	0.315	1.559	5.96	4.95	Single	0.313	St Pr. head 51B464-5A8
675	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.120	0.313	0.932	5.99	2.98	Single	0.313	St Pr. head 51B464-5A8
676	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.120	0.314	0.935	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
677	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.119	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
678	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.122	0.311	0.937	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
679	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.120	0.315	0.938	5.95	2.98	Single	0.313	St Pr. head 51B464-5A8
680	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.876	0.120	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
681	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.118	0.311	0.936	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
682	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.120	0.315	0.938	5.95	2.98	Single	0.313	St Pr. head 51B464-5A8
683	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.874	0.119	0.311	0.935	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
684	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	0.626	0.116	0.312	0.937	4.01	3.00	Single	0.313	St Pr. head 51B464-5A8
685	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	0.625	0.119	0.312	0.943	2.00	3.02	Single	0.313	St Pr. head 51B464-5A8
686	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	0.626	0.113	0.314	0.932	1.99	2.97	Single	0.313	St Pr. head 51B464-5A8
687	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.248	0.121	0.311	0.937	4.01	3.01	Single	0.313	St Pr. head 51B464-5A8
688	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.250	0.116	0.312	0.937	4.01	3.00	Single	0.313	St Pr. head 51B464-5A8
689	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.250	0.119	0.312	0.938	4.01	3.01	Single	0.313	St Pr. head 51B464-5A8
690	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	2.500	0.120	0.312	0.938	6.01	3.01	Single	0.313	St Pr. head 51B464-5A8
691	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	2.500	0.119	0.312	0.936	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
692	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	2.500	0.118	0.312	0.938	6.01	3.01	Single	0.313	St Pr. head 51B464-5A8
693	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.876	0.120	0.315	0.936	5.96	2.97	Single	0.313	St Csk-T 51B335-9
694	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.876	0.117	0.315	0.940	5.96	2.98	Single	0.313	St Csk-T 51B335-9
695	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.876	0.112	0.316	0.936	5.94	2.96	Single	0.313	St Csk-T 51B335-9
696	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.877	0.116	0.315	0.943	5.96	2.99	Single	0.313	St Csk-S 51B581-5-6
697	AS1/3501-6	50/40/10	[45/0/-45/0/2/0/90]s	1.875	0.113	0.314	0.935	5.97	2.98	Single	0.313	St Csk-S 51B581-5-6
698	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	0.626	0.117	0.312	0.941	2.01	3.02	Single	0.313	St Pr. head 51B464-5A8
699	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	0.624	0.117	0.311	0.935	2.01	3.01	Single	0.313	St Pr. head 51B464-5A8
700	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	0.626	0.118	0.312	0.939	2.01	3.01	Single	0.313	St Pr. head 51B464-5A8

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
657	100 RT		0.00	2628	21.06	69.2	3.5	11.6	23.3		941 Sher, Ten	143.0	Ramkumar...[1-25]	
658	100 RT		0.00	2462	23.59	72.6	4.0	12.2	24.1		885 Sher, Del	160.0	Ramkumar...[1-25]	
659	100 RT		0.00	2384	16.19	64.3	2.7	10.8	21.4		896 Shear	108.0	Ramkumar...[1-25]	
660	100 RT		0.00	5061	83.53	132.1	14.0	22.1	13.3		1807 Shear	185.0	Ramkumar...[1-25]	
661	100 RT		0.00	4720	110.77	131.0	18.5	21.9	13.2		1806 Shear		Ramkumar...[1-25]	
662	100 RT		0.00	5208	90.89	139.4	15.2	23.3	14.0		1998 Shear	188.0	Ramkumar...[1-25]	
663	100 RT		0.00	3449	44.89	91.1	7.5	15.2	15.2		1237 Shear		Ramkumar...[1-25]	Ten. head Csk depth = .10"
664	100 RT		0.00	3332	55.38	87.9	9.3	14.8	14.8		1201 Shear	98.0	Ramkumar...[1-25]	Ten. head Csk depth = .10"
665	100 RT		0.00	3156	34.97	84.9	5.9	14.3	14.3		1161 Shear	85.0	Ramkumar...[1-25]	Ten. head Csk depth = .10"
666	100 RT		0.00	3073	36.90	81.0	6.1	13.4	13.4		1116 Shear		Ramkumar...[1-25]	
667	100 RT		0.00	2999	26.46	79.3	4.4	13.3	13.3		1096 Shear	190.0	Ramkumar...[1-25]	Shear head Csk depth = .07"
668	100 RT		0.00	3341	32.11	89.4	5.4	15.0	14.9		1232 Sher, Del	167.0	Ramkumar...[1-25]	Shear head Csk depth = .07"
669	100 RT		0.00	3390	85.64	90.7	14.3	15.2	30.5		2118 Clev, Del	140.0	Ramkumar...[1-25]	
670	100 RT		0.00	3478	74.93	93.1	12.5	15.6	31.2		2190 Clev, Del	145.0	Ramkumar...[1-25]	
671	100 RT		0.00	3371	77.61	90.2	13.0	15.1	30.1		2173 Clev, Del	148.0	Ramkumar...[1-25]	
672	100 RT		0.00	5237	98.20	139.0	16.4	23.3	14.0		3246 Bear, Spl	167.0	Ramkumar...[1-25]	
673	100 RT		0.00	5374	104.37	143.8	17.5	24.1	24.2		3309 Bear, Spl	182.0	Ramkumar...[1-25]	
674	100 RT		0.00	5169	103.17	136.7	17.3	23.0	13.8		3289 Bear, Spl	182.0	Ramkumar...[1-25]	
675	100 RT		0.00	4636	53.25	123.4	8.9	20.6	20.7		2082 Bear, Spl		Ramkumar...[1-25]	Ten. head Csk depth = .10"
676	100 RT		0.00	3488	66.35	92.6	11.1	15.5	15.5		2173 Bear	143.0	Ramkumar...[1-25]	Shear head Csk depth = .07"
677	100 RT		0.00	3278	61.55	87.7	10.3	14.7	14.7		2063 Bolt Tens	114.0	Ramkumar...[1-25]	Shear head Csk depth = .07"
678	100 RT		0.00	4025	52.71	106.1	8.7	17.6	17.6		1476 Shear		Ramkumar...[1-25]	
679	100 RT		0.00	4128	82.01	109.2	13.8	18.3	18.3		1482 Shear	185.0	Ramkumar...[1-25]	
680	100 RT		0.00	4094	95.54	108.7	16.0	18.2	18.2		1482 Sher, Del	182.0	Ramkumar...[1-25]	
681	100 RT		0.00	5241	111.72	142.8	18.5	23.7	23.7		3279 Bear, Spl		Ramkumar...[1-25]	
682	100 RT		0.00	5139	103.17	136.0	17.3	22.6	22.8		3216 Bear, Spl	171.0	Ramkumar...[1-25]	
683	100 RT		0.00	5071	94.57	137.0	15.7	22.7	22.8		3290 Bear, Spl	167.0	Ramkumar...[1-25]	
684	100 RT		0.00	2951	33.16	81.5	16.5	40.6	13.6		3859 Tens	70.0	Ramkumar...[1-25]	
685	100 RT		0.00	2785	70.03	75.0	35.0	37.4	12.4		3694 Tens	87.0	Ramkumar...[1-25]	
686	100 RT		0.00	2833	26.18	79.8	14.1	40.0	13.4		3682 Tens	75.0	Ramkumar...[1-25]	
687	100 RT		0.00	4406	82.38	117.1	20.5	29.2	19.4		2917 Del	148.0	Ramkumar...[1-25]	
688	100 RT		0.00	4612	69.08	127.4	17.2	31.8	21.2		3227 Clev	162.0	Ramkumar...[1-25]	
689	100 RT		0.00	4783	94.27	128.8	23.5	32.2	21.4		3153 Tens, Del	143.0	Ramkumar...[1-25]	
690	100 RT		0.00	4773	82.80	127.5	10.3	15.9	21.2		1712 Sher, Del	200.0	Ramkumar...[1-25]	
691	100 RT		0.00	4577	91.58	123.3	11.4	15.4	20.5		1666 Sher, Del	210.0	Ramkumar...[1-25]	
692	100 RT		0.00	4763	76.05	129.9	9.5	16.2	21.6		1688 Sher, Del	207.0	Ramkumar...[1-25]	
693	100 RT		0.00	4358	31.75	115.3	5.3	19.4	19.4		1902 Sher, Clev	181.0	Ramkumar...[1-25]	Ten. head Csk depth = .10"
694	100 RT		0.00	4690	46.13	127.3	7.7	21.4	21.3	Unknown	Del, Clev	222.0	Ramkumar...[1-25]	Ten. head Csk depth = .10"
695	100 RT		0.00	4138	56.51	116.9	9.5	19.7	19.7		1862 Sh, Clev, Del		Ramkumar...[1-25]	Ten. head Csk depth = .10"
696	100 RT		0.00	3556	41.05	97.3	6.9	16.3	16.3		1637 Bear	186.0	Ramkumar...[1-25]	Shear head Csk depth = .07"
697	100 RT		0.00	3595	53.55	101.3	9.0	17.0	17.0		1624 Bear		Ramkumar...[1-25]	Shear head Csk depth = .07"
698	100 RT		0.00	3254	68.49	89.1	34.1	44.4	14.8		3298 Tens	99.0	Ramkumar...[1-25]	
699	100 RT		0.00	3185	68.71	87.5	34.2	43.6	14.6		3330 Clev	100.0	Ramkumar...[1-25]	
700	100 RT		0.00	3131	65.19	85.0	32.5	42.4	14.1		3135 Tens	114.0	Ramkumar...[1-25]	

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
701	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.250	0.119	0.312	0.939	4.01	3.01	Single	0.313	St Pr. head 51B464-5A8
702	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.252	0.119	0.312	0.931	4.01	2.98	Single	0.313	St Pr. head 51B464-5A8
703	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.250	0.120	0.312	0.944	4.01	3.03	Single	0.313	St Pr. head 51B464-5A8
704	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	2.500	0.123	0.311	0.932	8.04	3.00	Single	0.313	St Pr. head 51B464-5A8
705	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	2.500	0.121	0.312	0.939	8.01	3.01	Single	0.313	St Pr. head 51B464-5A8
706	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	2.502	0.120	0.311	0.937	8.05	3.01	Single	0.313	St Pr. head 51B464-5A8
707	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.881	0.121	0.312	0.931	6.03	2.98	Single	0.313	St Pr. head 51B464-5A8
708	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.878	0.120	0.311	0.931	6.04	2.99	Single	0.313	St Pr. head 51B464-5A8
709	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.878	0.118	0.312	0.936	6.02	3.00	Single	0.313	St Pr. head 51B464-5A8
710	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.881	0.120	0.311	0.936	6.05	3.01	Single	0.313	St Pr. head 51B464-5A8
711	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.879	0.119	0.312	0.931	6.02	2.98	Single	0.313	St Pr. head 51B464-5A8
712	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.879	0.119	0.311	0.933	6.04	3.00	Single	0.313	St Pr. head 51B464-5A8
713	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	0.628	0.120	0.312	0.938	2.01	3.01	Single	0.313	St Pr. head 51B464-5A8
714	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	0.626	0.118	0.312	0.939	2.01	3.01	Single	0.313	St Pr. head 51B464-5A8
715	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.250	0.118	0.312	0.937	4.01	3.00	Single	0.313	St Pr. head 51B464-5A8
716	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.251	0.118	0.312	0.938	4.01	3.01	Single	0.313	St Pr. head 51B464-5A8
717	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.250	0.120	0.312	0.940	4.01	3.01	Single	0.313	St Pr. head 51B464-5A8
718	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	2.500	0.113	0.311	0.938	8.04	3.02	Single	0.313	St Pr. head 51B464-5A8
719	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	2.500	0.117	0.311	0.939	8.04	3.02	Single	0.313	St Pr. head 51B464-5A8
720	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	2.500	0.116	0.312	0.932	7.59	2.98	Single	0.313	St Pr. head 51B464-5A8
721	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.878	0.115	0.314	0.938	5.98	2.99	Single	0.313	St Pr. head 51B464-5A8
722	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.879	0.115	0.313	0.937	6.00	2.99	Single	0.313	St Pr. head 51B464-5A8
723	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.877	0.115	0.313	0.932	6.00	2.98	Single	0.313	St Pr. head 51B464-5A8
724	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.879	0.116	0.312	0.930	6.02	2.98	Single	0.313	St Pr. head 51B464-5A8
725	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.878	0.117	0.312	0.929	6.02	2.98	Single	0.313	St Pr. head 51B464-5A8
726	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.877	0.115	0.311	0.931	6.04	2.99	Single	0.313	St Pr. head 51B464-5A8
727	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.118	0.311	1.039	6.03	3.34	Single	0.313	St Pr. head 51B464-5A8
728	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.121	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
729	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.121	0.314	0.942	5.97	3.00	Single	0.313	St Pr. head 51B464-5A8
730	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.120	0.314	0.935	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
731	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.120	0.315	0.939	5.95	2.98	Single	0.313	St Pr. head 51B464-5A8
732	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.118	0.314	0.943	5.97	3.00	Single	0.313	St Pr. head 51B464-5A8
733	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.112	0.315	0.941	5.96	2.99	Single	0.313	St Pr. head 51B464-5A8
734	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.120	0.315	0.938	5.95	2.98	Single	0.313	St Pr. head 51B464-5A8
735	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.120	0.315	0.925	5.95	2.94	Single	0.313	St Pr. head 51B464-5A8
736	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.119	0.311	0.933	6.03	3.00	Single	0.313	St Pr. head 51B464-5A8
737	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.120	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
738	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.874	0.119	0.314	0.938	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
739	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.119	0.316	0.943	5.94	2.98	Single	0.313	St Pr. head 51B464-5A8
740	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.875	0.114	0.318	0.938	5.90	2.95	Single	0.313	St Pr. head 51B464-5A8
741	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.877	0.119	0.311	0.938	6.04	3.02	Single	0.313	St Pr. head 51B464-5A8
742	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.877	0.119	0.314	0.943	5.98	3.00	Single	0.313	St Pr. head 51B464-5A8
743	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.876	0.114	0.315	0.940	5.96	2.99	Single	0.313	St Pr. head 51B464-5A8
744	AS1/3501-6	50/40/10	[(0/3/±45/0/2/±45/90]s	1.875	0.113	0.311	0.931	6.03	2.99	Single	0.313	St Pr. head 51B464-5A8

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
701	100	RT	0.00	3977	67.33	107.1	16.8	26.7	17.8	2073	Shear	129.0	Ramkumar...[1-25]	
702	100	RT	0.00	3058	72.72	82.4	18.1	20.5	13.8	1885	Shear	154.0	Ramkumar...[1-25]	
703	100	RT	0.00	4128	96.15	110.3	24.0	27.5	18.2	2183	Shear	200.0	Ramkumar...[1-25]	
704	100	RT	0.00	3889	67.97	101.7	8.5	12.6	17.0	1144	Shear	190.0	Ramkumar...[1-25]	
705	100	RT	0.00	4025	68.87	108.6	8.6	13.3	17.7	1239	Shear	214.0	Ramkumar...[1-25]	
706	100	RT	0.00	4221	80.39	113.1	10.0	14.1	18.8	1241	Shear	200.0	Ramkumar...[1-25]	
707	100	218	1.094	2853	58.28	75.6	9.7	12.5	12.7	1032	Clev, Del	71.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
708	100	218	1.094	2814	61.63	75.4	10.2	12.5	12.6	1085	Shear	64.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
709	100	218	1.094	3063	57.04	83.2	9.5	13.8	13.9	1144	Shear	73.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
710	100	218	1.094	3063	40.19	82.1	6.8	13.6	13.6	1144	Ten-Clev	77.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
711	100	218	1.094	2745	53.87	73.9	8.9	12.3	12.4	1013	Ten-Clev	70.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
712	100	218	1.094	2750	35.42	74.9	5.9	12.4	12.5	1044	Ten-Clev	80.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
713	100	RT	0.00	2203	58.76	58.8	29.3	29.3	9.8	4066	Tens	74.0	Ramkumar...[1-25]	
714	100	RT	0.00	2208	57.04	60.0	28.4	29.9	10.0	4160	Tens	82.0	Ramkumar...[1-25]	
715	100	RT	0.00	5120	105.93	139.1	26.4	34.7	23.2	4728	Bear, Spl	83.0	Ramkumar...[1-25]	
716	100	RT	0.00	4675	100.50	127.0	25.1	31.7	21.1	4405	Bear, Spl	130.0	Ramkumar...[1-25]	
717	100	RT	0.00	4866	98.82	130.0	24.7	32.4	23.6	4444	Bear, Spl	136.0	Ramkumar...[1-25]	
718	100	RT	0.00	5129	99.79	142.2	12.4	17.7	23.6	2522	Bear, Spl	188.0	Ramkumar...[1-25]	
719	100	RT	0.00	4748	93.44	130.5	11.6	16.2	21.6	2224	Bear, Spl	182.0	Ramkumar...[1-25]	
720	100	RT	0.00	4768	55.08	131.3	6.9	16.4	22.1	2319	Bear, Spl	190.0	Ramkumar...[1-25]	
721	100	218	0.908	4255	58.18	117.8	9.7	19.7	19.7	2318	Bear, Spl	80.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
722	100	218	0.908	3908	61.12	108.6	10.2	18.1	18.1	2649	Bear, Spl	75.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
723	100	218	0.908	3930	47.23	106.4	7.9	17.7	17.9	2627	Bear, Spl	75.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
724	100	218	0.908	4030	80.13	111.4	13.3	18.5	18.7	2560	Bear, Spl	74.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
725	100	218	0.908	3981	63.01	109.1	10.5	18.1	18.3	2955	Bear, Spl	71.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
726	100	218	0.908	4475	64.31	125.1	10.7	20.7	20.9	3031	Bear, Spl	86.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
727	0	RT	0.00	4851	89.92	132.2	14.9	21.9	19.8	2229	Sh, Cl, Spl	185.0	Ramkumar...[1-25]	
728	0	RT	0.00	4529	81.59	119.2	13.7	20.0	20.0	2044	Bear	167.0	Ramkumar...[1-25]	
729	0	RT	0.00	4946	78.98	127.5	13.2	21.4	21.3	2210	Del, Br, Cl	194.0	Ramkumar...[1-25]	
730	50	RT	0.00	4494	84.93	119.3	14.2	20.0	20.0	2076	Sh, Sp	143.0	Ramkumar...[1-25]	
731	50	RT	0.00	4850	76.72	123.0	12.9	20.7	20.8	2060	Del, Cl, Br	174.0	Ramkumar...[1-25]	
732	50	RT	0.00	4670	78.27	126.0	13.1	21.1	21.0	2150	Sh, Del	176.0	Ramkumar...[1-25]	
733	150	RT	0.00	5268	116.21	149.3	19.5	25.1	25.0	2325	Sh, Del	200.0	Ramkumar...[1-25]	
734	150	RT	0.00	4700	100.53	124.3	16.9	20.9	20.9	2102	Sh, Cl, Sp	222.0	Ramkumar...[1-25]	
735	150	RT	0.00	4836	97.88	127.9	16.4	21.5	21.8	2158	Del, Cl	185.0	Ramkumar...[1-25]	
736	200	RT	0.00	5002	102.68	135.2	17.0	22.4	22.5	2307	Br, Sp	180.0	Ramkumar...[1-25]	
737	200	RT	0.00	4758	100.85	126.3	16.9	21.1	21.2	2094	Sh, Sp	194.0	Ramkumar...[1-25]	
738	200	RT	0.00	4831		129.3		21.7	21.7	2180	Sher		Ramkumar...[1-25]	
739	100	RT	0.00	4221	79.78	112.2	13.4	18.9	18.8	1910	Sh, Del	75.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
740	100	RT	0.00	3752	71.72	103.5	12.2	17.6	17.5	1680	Bolt Tens		Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
741	100	RT	0.00	3210	70.25	86.7	11.6	14.4	14.4	1512	Bear	143.0	Ramkumar...[1-25]	Ti Sher. head Csk depth = .07
742	100	RT	0.00	3146	69.58	84.2	11.6	14.1	14.0	1438	Bear	133.0	Ramkumar...[1-25]	Ti Sher. head Csk depth = .07
743	100	RT	0.00	3097	72.40	86.2	12.2	14.5	14.5	1435	Split		Ramkumar...[1-25]	Ti Sher. head Csk depth = .07
744	100	RT	0.00	4719	85.37	134.3	14.2	22.3	22.4	2180	Shear		Ramkumar...[1-25]	

## Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
745	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.114	0.311	0.934	6.03	3.00	Single	0.313	St Pr. head 51B464-5A8
746	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.117	0.311	0.946	6.03	3.04	Single	0.313	St Pr. head 51B464-5A8
747	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.120	0.312	0.937	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
748	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.120	0.312	0.938	6.01	3.01	Single	0.313	St Pr. head 51B464-5A8
749	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.119	0.312	0.943	6.01	3.02	Single	0.313	St Pr. head 51B464-5A8
750	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.877	0.118	0.311	0.936	6.04	3.01	Single	0.313	St Pr. head 51B464-5A8
751	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.875	0.117	0.311	0.937	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
752	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.878	0.115	0.311	0.934	6.04	3.00	Single	0.313	St Pr. head 51B464-5A8
753	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.875	0.120	0.311	0.937	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
754	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.876	0.120	0.311	0.936	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
755	AS1/3501-6	70/20/10	[(0)3/±45/(0)4/±45/0]s	1.875	0.120	0.311	0.936	6.03	3.01	Single	0.313	St Pr. head 51B464-5A8
756	AS1/3501-6	30/60/10	[(±45)3/(0)3/90]s	1.875	0.117	0.312	0.947	6.02	3.04	Single	0.313	St Pr. head 51B464-5A8
757	AS1/3501-6	30/60/10	[(±45)3/(0)3/90]s	1.875	0.117	0.312	0.942	6.01	3.02	Single	0.313	St Pr. head 51B464-5A8
758	AS1/3501-6	30/60/10	[(±45)3/(0)3/90]s	1.876	0.117	0.312	0.937	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
759	AS1/3501-6	30/60/10	[(±45)3/(0)3/90]s	1.876	0.120	0.312	0.936	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
760	AS1/3501-6	30/60/10	[(0)±45/0/±45/90/±45/0]s	1.876	0.120	0.312	0.936	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
761	AS1/3501-6	30/60/10	[(0)±45/0/±45/90/±45/0]s	1.876	0.120	0.312	0.936	6.01	3.00	Single	0.313	St Pr. head 51B464-5A8
762	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.115	0.314	0.936	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
763	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.116	0.314	0.935	5.97	2.96	Single	0.313	St Pr. head 51B464-5A8
764	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.118	0.314	0.935	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
765	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.877	0.119	0.316	0.935	5.94	2.96	Single	0.313	St Pr. head 51B464-5A8
766	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.876	0.119	0.315	0.938	5.96	2.98	Single	0.313	St Pr. head 51B464-5A8
767	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.114	0.314	0.929	5.97	2.96	Single	0.313	St Pr. head 51B464-5A8
768	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.114	0.314	0.934	5.97	2.97	Single	0.313	St Pr. head 51B464-5A8
769	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.118	0.314	0.942	5.97	3.00	Single	0.313	St Pr. head 51B464-5A8
770	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.120	0.315	0.938	5.95	2.98	Single	0.313	St Pr. head 51B464-5A8
771	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.120	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
772	AS1/3501-6	50/40/10	[(0)3/±45/(0)2/±45/90]s	1.875	0.120	0.314	0.943	5.97	3.00	Single	0.313	St Pr. head 51B464-5A8
773	AS1/3501-6	70/20/10	[(45/0/-45/0/3/90/0/3]s	1.875	0.119	0.315	0.936	5.95	2.97	Single	0.313	St Pr. head 51B464-5A8
774	AS1/3501-6	70/20/10	[(45/0/-45/0/3/90/0/3]s	1.875	0.119	0.315	0.936	5.95	2.97	Single	0.313	St Pr. head 51B464-5A8
775	AS1/3501-6	70/20/10	[(45/0/-45/0/3/90/0/3]s	1.875	0.120	0.316	0.934	5.93	2.96	Single	0.313	St Pr. head 51B464-5A8
776	AS1/3501-6	30/60/10	[(45/0/-45/0/45/90/-45/0/45/-45]s	1.876	0.118	0.314	0.937	5.97	2.98	Single	0.313	St Pr. head 51B464-5A8
777	AS1/3501-6	30/60/10	[(45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.119	0.315	0.936	5.95	2.97	Single	0.313	St Pr. head 51B464-5A8
778	AS1/3501-6	30/60/10	[(45/0/-45/0/45/90/-45/0/45/-45]s	1.877	0.119	0.315	0.935	5.96	2.97	Single	0.313	St Pr. head 51B464-5A8
779	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.879	0.120	0.323	0.935	5.82	2.90	Single	0.313	St Pr. head 51B464-5A8
780	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.878	0.120	0.320	0.930	5.87	2.91	Single	0.313	St Pr. head 51B464-5A8
781	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.878	0.120	0.320	0.931	5.86	2.91	Single	0.313	St Pr. head 51B464-5A8
782	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.877	0.118	0.314	0.935	5.88	2.92	Single	0.313	St Pr. head 51B464-5A8
783	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.879	0.120	0.315	0.927	5.98	2.95	Single	0.313	St Pr. head 51B464-5A8
784	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.879	0.120	0.315	0.931	5.96	2.96	Single	0.313	St Pr. head 51B464-5A8
785	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	1.878	0.120	0.315	0.935	5.96	2.97	Single	0.313	St Pr. head 51B464-5A8
786	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	4.5/0	0.358	0.750	2.250	6.00	3.00	Single	0.750	St Pr. Hd 51B464-12A18
787	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	4.5/0	0.357	0.750	2.248	6.00	3.00	Single	0.750	St Pr. Hd 51B464-12A18
788	AS1/3501-6	50/40/10	[(45/0/-45/0/2/0/90]s	4.5/0	0.357	0.750	2.244	5.99	2.99	Single	0.750	St Pr. Hd 51B464-12A18

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
745	100	RT	0.00	4509	81.80	127.2	13.6	21.1	21.2	2020	Sh, Sp	185.0	Ramkumar...[1-25]	
746	100	RT	0.00	4812	52.22	132.2	8.7	21.9	21.7	2206	Shear	185.0	Ramkumar...[1-25]	
747	100	RT	0.00	4640	80.13	123.9	13.3	20.6	20.6	2144	Sh, Br, Sp	188.0	Ramkumar...[1-25]	
748	100	RT	0.00	4650	80.13	124.2	13.3	20.7	20.7	2044	Sh, Br, Sp	182.0	Ramkumar...[1-25]	
749	100	RT	0.00	4568		123.0		20.5	20.4	2118	Sh, Br, Sp		Ramkumar...[1-25]	
750	100	RT	0.00	4026	76.30	109.7	12.6	18.2	18.2	1562	Shear		Ramkumar...[1-25]	
751	100	RT	0.00	4074	76.95	112.0	12.8	18.6	18.6	1527	Shear	182.0	Ramkumar...[1-25]	
752	100	RT	0.00	4030	44.74	112.7	7.4	18.7	18.8	1512	Shear	240.0	Ramkumar...[1-25]	
753	100	RT	0.00	3962	75.03	106.2	12.4	17.6	17.6	1492	Shear		Ramkumar...[1-25]	
754	100	RT	0.00	3874	64.31	103.8	10.7	17.2	17.2	1431	Shear	222.0	Ramkumar...[1-25]	
755	100	RT	0.00	3810	69.67	102.1	11.6	16.9	17.0	1408	Shear	211.0	Ramkumar...[1-25]	
756	100	RT	0.00	4934	95.88	135.2	15.9	22.5	22.3	3134	Br, Sp		Ramkumar...[1-25]	
757	100	RT	0.00	4899	90.40	134.2	15.0	22.3	22.2	3126	Br, Sp	174.0	Ramkumar...[1-25]	
758	100	RT	0.00	4856	87.66	133.0	14.6	22.1	22.1	3163	Br, Sp	171.0	Ramkumar...[1-25]	
759	100	RT	0.00	5193	98.82	138.7	16.4	23.1	23.1	3341	Br, Sp		Ramkumar...[1-25]	
760	100	RT	0.00	5164	88.14	137.9	14.7	22.9	23.0	3358	Br, Sp	200.0	Ramkumar...[1-25]	
761	100	RT	0.00	5110	98.82	136.5	16.4	22.7	22.7	3260	Br, Sp	185.0	Ramkumar...[1-25]	
762	100	RT	0.00	4284	72.00	118.6	12.1	19.9	19.9	1954	Shear	88.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
763	100	RT	0.00	3928	79.62	107.8	13.3	18.1	18.1	1790	Sh, Br, Sp	108.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
764	100	RT	0.00	4265	86.37	115.1	14.5	19.3	19.3	2022	Cl, Del	83.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
765	100	RT	0.00	2745	26.59	73.0	4.5	12.3	12.3	1205	Bolt Ten		Ramkumar...[1-25]	Al Ten. head Csk depth = .10
766	100	RT	0.00	4250	26.68	113.4	4.5	19.0	19.0	1876	Del, Cl		Ramkumar...[1-25]	Al Ten. head Csk depth = .10
767	100	RT	0.00	3947	78.22	110.3	13.1	18.5	18.6	1827	Br, Sp		Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
768	100	RT	0.00	4318	75.43	120.6	12.6	20.2	20.3	2004	Sh, Sp	75.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
769	100	RT	0.00	4069	64.77	109.8	10.8	18.4	18.3	350	Sh, Sp	82.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
770	100	RT	0.00	3815	47.62	100.9	8.0	17.0	16.9	1746	Sh, Br, Cl	80.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
771	100	RT	0.00	3937	53.08	104.5	8.9	17.5	17.5	1771	Sh, Br, Cl	83.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
772	100	RT	0.00	3771	58.39	100.1	9.8	16.8	16.7	1701	Sh, Br, Cl	83.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
773	100	RT	0.00	3195	48.02	85.2	8.1	14.3	14.3	1100	Shear	70.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
774	100	RT	0.00	3283	42.19	86.8	7.1	14.6	14.7	1171	Shear	81.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
775	100	RT	0.00	3478	64.77	93.9	10.8	15.7	15.7	1234	Sh, Cl	100.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
776	100	RT	0.00	4035	74.70	107.8	12.5	18.1	18.1	Unknown	Bear	105.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
777	100	RT	0.00	4055	69.36	108.2	11.6	18.2	18.2	2529	Bolt Ten	75.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
778	100	RT	0.00	4323		116.3		19.5	19.5	2757	Bolt Ten	75.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
779	100	RT	0.996	3595	79.98	92.8	13.7	15.9	16.0	1590	Cl, Del		Ramkumar...[1-25]	St Ten. head Csk depth = .10
780	100	RT	0.938	4142	85.94	107.9	14.6	18.4	18.6	1865	Sh, Del	75.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
781	100	RT	0.978	4103	80.73	106.8	13.8	18.2	18.4	1824	Cl, Del	97.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
782	100	218	0.996	4025		108.6		18.2	18.2	1781	Bolt Ten	74.0	Ramkumar...[1-25]	Ti Ten. head Csk depth = .10
783	100	218	0.996	3591	55.73	95.3	9.3	15.9	16.1	1630	Br, Del	171.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
784	100	218	0.996	4016	68.78	106.2	11.5	17.8	18.0	1919	Sh, Del	74.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
785	100	218	0.978	4157	68.78	110.0	11.5	18.5	18.5	1909	Clev	79.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
786	100	RT	0.00	24231	39.11	90.2	6.5	15.0	15.0	1605	Sh, Del	75.0	Ramkumar...[1-25]	St Ten. head Csk depth = .10
787	100	RT	0.00	22716	44.82	84.8	7.5	14.1	14.2	1639	Sh, Del	630.0	Ramkumar...[1-25]	
788	100	RT	0.00	23498	40.28	87.6	6.7	14.6	14.7	1611	Sh, Del		Ramkumar...[1-25]	

Single J-Tension

	A	B	C	D	E	F	G	H	I	J	K	L
789	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]3s	4.500	0.355	0.750	2.258	6.00	3.01	Single	0.750	St Pr. Hd 51B464-12A18
790	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]3s	4.500	0.358	0.750	2.245	6.00	2.99	Single	0.750	St Pr. Hd 51B464-12A18
791	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]3s	4.500	0.352	0.750	2.242	6.00	2.99	Single	0.750	St Pr. Hd 51B464-12A18
792	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]2s	3.000	0.229	0.500	1.484	6.00	2.97	Single	0.750	St Ckt-T 51B338-13
793	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]3s	4.499	0.342	0.750	2.251	6.00	3.00	Single	0.750	St Pr. Hd 51B464-12A18
794	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]3s	4.499	0.344	0.751	2.254	5.99	3.00	Single	0.750	St Pr. Hd 51B464-12A18
795	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]3s	4.499	0.344	0.752	2.249	5.98	2.99	Single	0.750	St Pr. Hd 51B464-12A18
796	AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.877	0.118	0.312	0.937	6.02	3.00	Double	0.313	St Pr. head 51B464-5A8
797	AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.875	0.119	0.311	0.929	6.03	2.99	Double	0.313	St Pr. head 51B464-5A8
798	AS1/3501-6	50/40/10	[(45/0/-45/0)2/0/90]s	1.875	0.117	0.312	0.931	6.01	2.98	Double	0.313	St Pr. head 51B464-5A8
799	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.120	0.311	0.935	6.03	3.01	Double	0.313	St Pr. head 51B464-5A8
800	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.875	0.120	0.311	0.935	6.03	3.01	Double	0.313	St Pr. head 51B464-5A8
801	AS1/3501-6	70/20/10	[45/0/-45/0/3/90/0/3]s	1.877	0.123	0.311	0.937	6.04	3.01	Double	0.313	St Pr. head 51B464-5A8
802	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.874	0.119	0.311	0.936	6.03	3.01	Double	0.313	St Pr. head 51B464-5A8
803	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.875	0.118	0.311	0.932	6.03	3.00	Double	0.313	St Pr. head 51B464-5A8
804	AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]s	1.878	0.115	0.310	0.936	6.06	3.02	Double	0.313	St Pr. head 51B464-5A8

Single J-Tension

	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
788	100	RT	0.00	30044	67.61	112.8	11.3	18.8	18.7	2289	Sh, Del	530.0	Ramkumar...[1-25]	
790	100	RT	0.00	26185		97.5		16.3	16.3	2064	Del		Ramkumar...[1-25]	
791	100	RT	0.00	29287	57.58	110.9	9.6	18.5	18.6	2251	Sh, Del		Ramkumar...[1-25]	
792	100	RT	0.00	13854	54.15	119.2	9.0	19.9	20.1	2640	Bolt Ten	600.0	Ramkumar...[1-25]	Sl Ten. head Cek depth = .20"
793	100	RT	0.00	31192		121.6		20.3	20.3	3458	Br, Sp		Ramkumar...[1-25]	
794	100	RT	0.00	32462	53.42	125.7	8.9	21.0	20.9	3041			Ramkumar...[1-25]	
795	100	RT	0.00	31988		123.7		20.7	20.7	3307	Br, Sp	59.0	Ramkumar...[1-25]	
796	100	RT	0.00	4778		129.8		21.6	21.6	2108	Del	92.0	Ramkumar...[1-25]	
797	100	RT	0.00	4577	89.17	123.7	14.8	20.5	20.7	2188	Ten-clv		Ramkumar...[1-25]	
798	100	RT	0.00	4890	87.66	134.0	14.6	22.3	22.4	2217	Del	263.0	Ramkumar...[1-25]	
799	100	RT	0.00	4055	50.91	108.7	8.4	18.0	18.1	1540	Del, Sp	240.0	Ramkumar...[1-25]	
800	100	RT	0.00	3747	53.59	100.4	8.9	16.7	16.7	1396	Sher	283.0	Ramkumar...[1-25]	
801	100	RT	0.00	4133	78.43	108.0	13.0	17.9	17.9	1461	Sher	205.0	Ramkumar...[1-25]	
802	100	RT	0.00	5857	102.68	158.3	17.0	26.3	26.3	3708	Del	273.0	Ramkumar...[1-25]	
803	100	RT	0.00	6323	122.62	172.3	20.3	28.6	28.7	4027	Br, Del	218.0	Ramkumar...[1-25]	
804	100	RT	0.00	5721	103.79	160.5	17.1	26.5	26.6	3817	Bear	242.0	Ramkumar...[1-25]	

**Appendix 1-2. Data for single bolted-joints under  
bearing/bypass loading.**

## Bearing/Bypass

	A	B	C	D	E	G	H	I	J	K	L	M
1	Material	Percent of 0±45/90 plies	Stacking Sequence	Plate Width W (in.)	Plate Thickness t (in.)	Hole Diameter d (in.)	Joint Type	Fastener Diameter d (in.)	Fastener Type	Fastener Torque in-lbs	Loading	Bearing/ Total Loa Ratio
2	System											
3	Fiber/Resin											
4	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.876	0.120	0.312	6.01 Single				Bo,Sp-Tens	0
5	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.118	0.311	6.03 Single	0.312			Bo,Sp-Tens	0
6	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.874	0.120	0.310	6.05 Single	0.312			Bo,Sp-Tens	0
7	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.874	0.117	0.311	6.03 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.167
8	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.120	0.309	6.07 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.167
9	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.117	0.312	6.01 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.167
10	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.874	0.119	0.312	6.01 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.167
11	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.121	0.311	6.03 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.287
12	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.876	0.115	0.311	6.03 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.287
13	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.118	0.311	6.03 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.287
14	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.118	0.311	6.03 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.375
15	AS1/3501-6	50/40/10	[(45/0/-45/0)/2/0/90]s	1.875	0.118	0.312	6.01 Single	0.312	St Pr head 51B464-5A8	100	Bo,Sp-Tens	0.375
16	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.120	0.311	6.03 Single	0.312			Bo,Sp-Tens	0
17	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.876	0.119	0.312	6.01 Single	0.312			Bo,Sp-Tens	0
18	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.120	0.312	6.01 Single	0.312			Bo,Sp-Tens	0
19	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.120	0.312	6.01 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.167
20	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.874	0.119	0.312	6.01 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.167
21	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.876	0.118	0.311	6.03 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.167
22	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.119	0.312	6.01 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.287
23	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.873	0.119	0.312	6.00 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.287
24	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.118	0.311	6.03 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.287
25	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.117	0.312	6.01 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.287
26	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.875	0.118	0.312	6.01 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.375
27	AS1/3501-6	70/20/10	[(45/0/-45/0)/3/90/(0)3]s	1.876	0.118	0.311	6.03 Single	0.312	St Csk-T 51B335-9	100	Bo,Sp-Tens	0.375
28	AS1/3501-6	30/60/10	[(45/0/-45/0)/45/90/-45/0/(									

## Bearing/Bypass

		N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Test	Moisture	Failing	Bearing	Bearing	Bearing	Gross	Gross	Gross	Mode	Joint	Reference	Remarks	Initial
2	Temp	Content	Load	(Initial Non-	(Initial Non-	(P(b/d)	Strength	Strength	Remote	of	Stiffness			Nonlinear
3	ture	(% by Wt)	P(D, (lb.)	linearity)	linearity)	ksi	ksi	(P(Tj/Wj) ksi	Failure Strain		(kips/in.)			Load (kips)
4	RT	0.00	13190	0.0	0.0	0.0	0.0	58.6	5598	Tens		Rankumar... (1-25)	Open Hole	
5	RT	0.00	12335	0.0	0.0	0.0	0.0	55.8	5200	Tens		Rankumar... (1-25)	Open Hole	
6	RT	0.00	13161	0.0	0.0	0.0	0.0	58.5	5561	Tens		Rankumar... (1-25)	Open Hole	
7	RT	0.00	10318	22.9	47.4	47.4	22.8	49.8	4418	Tens	522	Rankumar... (1-25)		
8	RT	0.00	11197	24.3	50.4	50.4	24.0	49.8	4638	Tens	552	Rankumar... (1-25)		5.0
9	RT	0.00	10533	34.8	48.2	48.2	34.6	48.0	4283	Tens	545	Rankumar... (1-25)		5.4
10	RT	0.00	10454	44.1	80.8	80.8	25.6	46.9	2813	Ten, Del	470	Rankumar... (1-25)		5.7
11	RT	0.00	9858	68.6	75.2	75.2	39.7	43.5	4088	Tens	444	Rankumar... (1-25)		9.0
12	RT	0.00	9936	36.1	79.7	79.7	20.9	46.1	4354	Tens	488	Rankumar... (1-25)		4.5
13	RT	0.00	9643	36.8	98.5	98.5	16.3	43.6	3968	Tens	455	Rankumar... (1-25)		3.6
14	RT	0.00	9340	41.9	95.4	95.4	18.5	42.2	3974	Tens	345	Rankumar... (1-25)		4.1
15	RT	0.00	9341	71.3	95.1	95.1	31.6	42.2	3755	Tens	417	Rankumar... (1-25)		7.0
16	RT	0.00	20225	0.0	0.0	0.0	0.0	89.9	6417	Tens			Open Hole	
17	RT	0.00	19404	0.0	0.0	0.0	0.0	86.9	6196	Del			Open Hole	
18	RT	0.00	22789	0.0	0.0	0.0	0.0	101.3	7180	Tens			Open Hole	
19	RT	0.00	15730	29.4	70.2	70.2	29.3	69.9	3554	Te, Del, Cl	760	Rankumar... (1-25)	SI Ten. head Csk depth = .10	6.6
20	RT	0.00	17567	17.1	79.0	79.0	17.0	78.6	4228	Te, Cl		Rankumar... (1-25)	SI Ten. head Csk depth = .10	3.8
21	RT	0.00	14392	26.8	65.5	65.5	26.7	65.0	1900	De, Cl	445	Rankumar... (1-25)	SI Ten. head Csk depth = .10	5.9
22	RT	0.00	12907	27.8	99.8	99.8	16.1	57.8	1225	Te, Cl	583	Rankumar... (1-25)	SI Ten. head Csk depth = .10	3.6
23	RT	0.00	11510	25.5	89.0	89.0	14.8	51.6	3261	Te, Del, Cl	462	Rankumar... (1-25)	SI Ten. head Csk depth = .10	3.3
24	RT	0.00	13483	26.6	105.4	105.4	15.4	60.9	1796	Te, Del, Cl	541	Rankumar... (1-25)	SI Ten. head Csk depth = .10	3.4
25	RT	0.00	11797	48.3	121.2	121.2	21.4	53.8		Br, Sp	553	Rankumar... (1-25)	SI Ten. head Csk depth = .10	4.7
26	RT	0.00	12433	34.6	126.6	126.6	15.4	56.2	2018	Br, Sp	467	Rankumar... (1-25)	SI Ten. head Csk depth = .10	3.4
27	RT	0.00	10620	20.4	108.5	108.5	0.0	48.0		Br, Sp	522	Rankumar... (1-25)	SI Ten. head Csk depth = .10	2.0
28	RT	0.00	9697	0.0	0.0	0.0	0.0	45.4	5953	Tens		Rankumar... (1-25)	Open Hole	
29	RT	0.00	10708	0.0	0.0	0.0	0.0	48.0	6440	Tens		Rankumar... (1-25)	Open Hole	
30	RT	0.00	10454	0.0	0.0	0.0	0.0	46.9		Tens		Rankumar... (1-25)	Open Hole	
31	RT	0.00	9311	11.6	43.3	43.3	11.6	43.2	5554	Tens	667	Rankumar... (1-25)	TI Shr. head Csk depth = .07	2.5
32	RT	0.00	9115	18.2	42.4	42.4	18.1	42.3	6605	Tens	406	Rankumar... (1-25)	TI Shr. head Csk depth = .07	3.9
33	RT	0.00	8828		40.4	40.4	40.2	40.2	5214	Tens		Rankumar... (1-25)	TI Shr. head Csk depth = .07	
34	RT	0.00	8983	41.6	71.9	71.9	24.1	41.7	5405	Tens	335	Rankumar... (1-25)	TI Shr. head Csk depth = .07	5.2
35	RT	0.00	9233	52.8	73.9	73.9	30.6	42.9	5604	Tens	278	Rankumar... (1-25)	TI Shr. head Csk depth = .07	6.6
36	RT	0.00	9105	47.2	71.6	71.6	27.3	41.5	7673	Tens	307	Rankumar... (1-25)	TI Shr. head Csk depth = .07	6.0
37	RT	0.00	8622	60.6	90.1	90.1	26.9	40.0	5120	Tens	384	Rankumar... (1-25)	TI Shr. head Csk depth = .07	5.8
38	RT	0.00	8402	52.3	87.8	87.8	23.2	39.0	4910	Tens	267	Rankumar... (1-25)	TI Shr. head Csk depth = .07	5.0
39	RT	0.00	8862	54.4	91.0	91.0	24.2	40.4	5262	Tens	335	Rankumar... (1-25)	TI Shr. head Csk depth = .07	5.3
40	RT	0.00	-13508	0.0	0.0	0.0	0.0	-59.6	-6593	Comp		Rankumar... (1-25)	Open Hole	
41	RT	0.00	-13522	0.0	0.0	0.0	0.0	-60.6	-5861	Comp		Rankumar... (1-25)	Open Hole	
42	RT	0.00	-13141	0.0	0.0	0.0	0.0	-58.9	-6250	Comp		Rankumar... (1-25)	Open Hole	
43	RT	0.00	-16190	-36.6	-87.2	-87.2	-30.5	-72.6	-7713	Off-Co, Ck	649	Rankumar... (1-25)		-6.8
44	RT	0.00	-14411	-50.2	-77.0	-77.0	-41.8	-64.0	-6936	Comp	526	Rankumar... (1-25)		-9.4
45	RT	0.00	-11568		-62.8			-52.3	-4428	Comp		Rankumar... (1-25)		
46	RT	0.00	-11510	-37.8	-101.3	-101.3	-19.0	-50.8	-5171	Comp	533	Rankumar... (1-25)		-4.3
47	RT	0.00	-11539	-63.1	-104.1	-104.1	-31.7	-52.2	-5163	Comp	444	Rankumar... (1-25)		-7.0
48	RT	0.00	-11553	-62.0	-103.9	-103.9	-31.2	-52.2	-5112	Comp	414	Rankumar... (1-25)		5.0

	A	B	C	D	E	F	G	H	I	J	K	L	M
49	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.876	0.119	0.311	0.38	Single	0.312			Bo, Sp=Comp	0
50	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.12	0.311	0.38	Single	0.312			Bo, Sp=Comp	0
51	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.118	0.312	0.38	Single	0.312			Bo, Sp=Comp	0
52	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.119	0.314	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.2
53	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.118	0.313	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.2
54	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.119	0.313	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.2
55	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.117	0.312	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.33
56	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.118	0.314	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.33
57	AS1/3501-6	70/20/10	45/0/-45/0/3/90/0/3/s	1.875	0.119	0.312	0.38	Single	0.312	St Csk-T 51B335-9	100	Bo, Sp=Comp	0.33
58	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.875	0.115	0.312	0.37	Single	0.312			Bo, Sp=Comp	0
59	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.873	0.118	0.312	0.38	Single	0.312			Bo, Sp=Comp	0
60	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.875	0.119	0.312	0.38	Single	0.312			Bo, Sp=Comp	0
61	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.874	0.114	0.312	0.37	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.2
62	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.873	0.119	0.311	0.38	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.2
63	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.876	0.113	0.312	0.36	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.2
64	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.876	0.113	0.312	0.36	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.33
65	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.873	0.119	0.312	0.38	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.33
66	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/45/s	1.872	0.118	0.312	0.38	Single	0.312	Ti Csk-S NAS1581V5-8	100	Bo, Sp=Comp	0.33
67	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=0, S=1	0
68	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=1, S=1	0.128
69	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=3, S=1	0.306
70	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=1, S=0	1
71	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=0, S=1	0
72	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=1, S=1	-0.172
73	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=3, S=1	-0.787
74	T300/N5208	25/50/25	0/45/90/-45/2s	1.969	App. 0.08	0.252	7.81	Single	0.249	St bolt		B=1, S=0	1
75	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.10
76	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.20
77	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	1.00
78	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.10
79	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.20
80	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	1.00
81	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.10
82	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.20
83	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	1.00
84	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.133
85	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.267
86	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	1.00
87	AS1/3501-6	25/50/25	45/0/90/3s	1.50	0.12	0.192	7.81	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.20
88	AS1/3501-6	25/50/25	45/0/90/3s	1.125	0.12	0.192	5.86	Single	0.192	Ti 100° Csk-T HL13VAP6		Bo, Sp= Tens	0.40

Bearing/Bypass

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
49	RT	0.00	-19922	0.0	0.0	0	-89.2	-7309	Co, Cl		Ramkumar...[1-25]	Open Hole	
50	RT	0.00	-18857	0.0	0.0	0	-83.8	-7058	Off-Comp		Ramkumar...[1-25]	Open Hole	
51	RT	0.00	-13825	0.0	0.0	0	-62.5		Comp		Ramkumar...[1-25]	Open Hole	
52	RT	0.00	-16190	-64.2	-86.7	-53.8	-72.6	-5685	Comp	419	Ramkumar...[1-25]		-12.0
53	RT	0.00	-15710		-85.1		-71.0	-5268	Comp		Ramkumar...[1-25]		
54	RT	0.00	-15183	-40.3	-81.5	-33.6	-68.0	-5306	Comp		Ramkumar...[1-25]		-7.5
55	RT	0.00	-13218	-73.2	-119.5	-36.9	-60.3	-4436	Br, Sp	368	Ramkumar...[1-25]		-8.1
56	RT	0.00	-11451	-70.4	-102.0	-35.7	-51.8	-3879	Off-Comp	320	Ramkumar...[1-25]		-7.9
57	RT	0.00	-12450		-110.7		-55.8				Ramkumar...[1-25]		
58	RT	0.00	-9257	0.0	0.0	0	-42.9	-6031	Comp		Ramkumar...[1-25]	Open Hole	
59	RT	0.00	-11060	0.0	0.0	0	50.0	-7682	Comp		Ramkumar...[1-25]	Open Hole	
60	RT	0.00	-11119	0.0	0.0	0	-49.8	-7623	Off-Comp		Ramkumar...[1-25]	Open Hole	
61	RT	0.00	-9970	-27.0	-56.1	-22.5	-46.7	-6734	Off-Comp	357	Ramkumar...[1-25]		-4.8
62	RT	0.00	-11919	-55.1	-64.4	-45.8	-53.5	-8036	Off-Comp	326	Ramkumar...[1-25]		-10.2
63	RT	0.00	-10552	-44.3	-56.4	-36.9	-46.9	-6999	Off-Comp	288	Ramkumar...[1-25]		-8.3
64	RT	0.00	-8304	-61.8	-77.7	-31.1	-39.2	-5357	Bear	253	Ramkumar...[1-25]		-6.6
65	RT	0.00	-8866	-56.9	-78.8	-28.7	-39.8	-5708	Br, Del	250	Ramkumar...[1-25]		-6.4
66	RT	0.00	-8744	-63.6	-78.4	-32.1	-39.6	-5973	Br, Sp	270	Ramkumar...[1-25]		-7.1
67	RT	Unknown		0	0	38.5	41.7	Unknown	Tens	Unknown	Nalk, Crews, Jr. [1-45]	Open Hole	
68	RT	Unknown		34.4	36.1	34.4	39.1	Unknown	Tens	Unknown	Nalk, Crews, Jr. [1-45]	Finger light bo., Fit cl = 003*	
69	RT	Unknown		67.9	94.0	28.4	39.3	Unknown	Tens	Unknown	Nalk, Crews, Jr. [1-45]	Finger light bo., Fit cl = 003*	
70	RT	Unknown		78.6	117.8	10.1	15.1	Unknown	Bear	Unknown	Nalk, Crews, Jr. [1-45]	Bolt Loading	
71	RT	Unknown		0	0	-53.4	-53.4	Unknown	Comp	Unknown	Nalk, Crews, Jr. [1-45]	Open Hole	
72	RT	Unknown		45.5	66.9	-33.9	-49.8	Unknown	Off-comp	Unknown	Nalk, Crews, Jr. [1-45]	Finger light bo., Fit cl = 003*	
73	RT	Unknown		72.2	110.1	-11.7	-17.9	Unknown	Off-comp	Unknown	Nalk, Crews, Jr. [1-45]	Finger light bo., Fit cl = 003*	
74	RT	Unknown		76.6	123.7	9.8	15.8	Unknown	Bear	Unknown	Nalk, Crews, Jr. [1-45]	Bolt Loading	
75	RT	0	6624	Unknown	287.5	Unknown	36.8	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
76	RT	0	6444	Unknown	279.7	Unknown	35.8	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
77	RT	0	2736	Unknown	118.8	Unknown	15.2	Unknown	Bear	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
78	RT	1.0	6750	Unknown	293.0	Unknown	37.5	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
79	RT	1.0	6768	Unknown	293.8	Unknown	37.6	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
80	RT	1.0	2538	Unknown	110.2	Unknown	14.1	Unknown	Bear	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
81	RT	0	7002	Unknown	303.9	Unknown	38.9	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
82	RT	0	6534	Unknown	283.6	Unknown	36.3	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
83	RT	0	2916	Unknown	126.6	Unknown	16.2	Unknown	Bear	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
84	RT	0	6102	Unknown	264.8	Unknown	23.9	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
85	RT	0	5328	Unknown	231.3	Unknown	29.6	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
86	RT	0	3528	Unknown	153.1	Unknown	19.6	Unknown	Bear	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
87	RT	0	5706	Unknown	247.7	Unknown	31.7	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	
88	RT	0	4320	Unknown	187.5	Unknown	32	Unknown	Tens	Unknown	Ramkumar [1-41]	Average of 2 specimens.	

**Appendix A-3. Data for multiple bolted-joints in composites.**

### Multiple Choice

A		B		C		D		E		F		G		H		I		J		K		L		M		N		O		
1	Material	Percent of	Stacking	Sequence	W (in.)	Plate	Thickness	Avg. Hole	End	Distance	Fastener	Pitch	Back	W/K	Coiled	Ratio	Joint	Type	Ratio	Joint	Type	Ratio	Joint	Type	Ratio	Joint	Type	Ratio	Joint	Type
2	System	0/45/90	0/45/90	0/45/90	W (in.)	t (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)	d (in.)
3	Fiber/Resin	0/45/90/45	0/45/90/45	0/45/90/45	0.992	0.181	0.253	1.000	2 x 1	N/A	1.500	3.953	Double	0.253	11	0.253	11	0.253	11	0.253	11	0.253	11	0.253	11	0.253	11	0.253	11	0.253
4	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.004	0.182	0.257	1.000	2 x 1	N/A	1.500	3.907	Double	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257
5	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.005	0.182	0.254	1.000	2 x 1	N/A	1.500	3.957	Double	0.254	11	0.254	11	0.254	11	0.254	11	0.254	11	0.254	11	0.254	11	0.254	11	0.254
6	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.001	0.183	0.257	1.000	2 x 1	N/A	1.500	3.895	Double	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257	11	0.257
7	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.009	0.1817	0.2506	1.000	2 x 1	N/A	1.500	4.026	Double	0.2506	11	0.2506	11	0.2506	11	0.2506	11	0.2506	11	0.2506	11	0.2506	11	0.2506	11	0.2506
8	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.010	0.1858	0.2534	1.000	2 x 1	N/A	1.500	4.026	Double	0.2534	11	0.2534	11	0.2534	11	0.2534	11	0.2534	11	0.2534	11	0.2534	11	0.2534	11	0.2534
9	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.007	0.1791	0.2513	1.000	2 x 1	N/A	1.500	3.986	Double	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513
10	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.005	0.189	0.2512	1.000	2 x 1	N/A	1.500	4.007	Double	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512
11	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.002	0.1676	0.2522	1.000	2 x 1	N/A	1.500	3.973	Double	0.2522	11	0.2522	11	0.2522	11	0.2522	11	0.2522	11	0.2522	11	0.2522	11	0.2522	11	0.2522
12	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.001	0.1701	0.2518	1.000	2 x 1	N/A	1.500	3.973	Double	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518
13	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.002	0.1701	0.2508	1.000	2 x 1	N/A	1.500	3.973	Double	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508
14	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.002	0.1864	0.2567	1.000	2 x 1	N/A	1.500	3.923	Double	0.2567	11	0.2567	11	0.2567	11	0.2567	11	0.2567	11	0.2567	11	0.2567	11	0.2567	11	0.2567
15	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	0.996	0.178	0.2524	1.000	2 x 1	N/A	1.500	3.958	Double	0.2524	11	0.2524	11	0.2524	11	0.2524	11	0.2524	11	0.2524	11	0.2524	11	0.2524	11	0.2524
16	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	0.996	0.1778	0.2536	1.000	2 x 1	N/A	1.500	3.939	Double	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536
17	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.005	0.1775	0.2503	1.000	2 x 1	N/A	1.500	3.979	Double	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503
18	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.000	0.177	0.2513	1.000	2 x 1	N/A	1.500	3.999	Double	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513	11	0.2513
19	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.005	0.1754	0.2512	1.000	2 x 1	N/A	1.500	3.989	Double	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512
20	GI/T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.003	0.1736	0.2503	1.000	2 x 1	N/A	1.500	4.007	Double	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503
21	GI/T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	0.997	0.1785	0.2512	1.000	2 x 1	N/A	1.500	3.989	Double	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512
22	GI/T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.005	0.1768	0.2503	1.000	2 x 1	N/A	1.500	4.018	Double	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503
23	GI/T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.002	0.1769	0.2503	1.000	2 x 1	N/A	1.500	4.003	Double	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503	11	0.2503
24	GI/T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.002	0.1793	0.2516	1.000	2 x 1	N/A	1.500	3.979	Double	0.2516	11	0.2516	11	0.2516	11	0.2516	11	0.2516	11	0.2516	11	0.2516	11	0.2516	11	0.2516
25	GI/T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.004	0.1794	0.2508	1.000	2 x 1	N/A	1.500	4.003	Double	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508	11	0.2508
26	GI/T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	0.998	0.1724	0.2505	1.000	2 x 1	N/A	1.500	3.984	Double	0.2505	11	0.2505	11	0.2505	11	0.2505	11	0.2505	11	0.2505	11	0.2505	11	0.2505	11	0.2505
27	GI/T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	0.997	0.185	0.2589	1.000	2 x 1	N/A	1.500	3.891	Double	0.2589	11	0.2589	11	0.2589	11	0.2589	11	0.2589	11	0.2589	11	0.2589	11	0.2589	11	0.2589
28	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.003	0.1631	0.259	1.000	2 x 1	N/A	1.500	3.873	Double	0.259	11	0.259	11	0.259	11	0.259	11	0.259	11	0.259	11	0.259	11	0.259	11	0.259
29	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.005	0.1724	0.2536	1.000	2 x 1	N/A	1.500	3.963	Double	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536	11	0.2536
30	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	0.997	0.1835	0.256	1.000	2 x 1	N/A	1.500	3.895	Double	0.256	11	0.256	11	0.256	11	0.256	11	0.256	11	0.256	11	0.256	11	0.256	11	0.256
31	T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.003	0.1937	0.2504	1.000	2 x 1	N/A	1.500	4.006	Double	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504
32	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.002	0.1812	0.2507	1.000	2 x 1	N/A	1.500	3.987	Double	0.2507	11	0.2507	11	0.2507	11	0.2507	11	0.2507	11	0.2507	11	0.2507	11	0.2507	11	0.2507
33	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	1.001	0.185	0.2525	1.000	2 x 1	N/A	1.500	3.964	Double	0.2525	11	0.2525	11	0.2525	11	0.2525	11	0.2525	11	0.2525	11	0.2525	11	0.2525	11	0.2525
34	T300/N5208	37.5/37.5/25	0/45/90/45	0/45/90/45	0.996	0.1929	0.2512	1.000	2 x 1	N/A	1.500	3.941	Double	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512	11	0.2512
35	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.004	0.1846	0.2532	1.000	2 x 1	N/A	1.500	3.965	Double	0.2532	11	0.2532	11	0.2532	11	0.2532	11	0.2532	11	0.2532	11	0.2532	11	0.2532	11	0.2532
36	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.020	0.1805	0.2548	1.000	2 x 1	N/A	1.500	4.003	Double	0.2548	11	0.2548	11	0.2548	11	0.2548	11	0.2548	11	0.2548	11	0.2548	11	0.2548	11	0.2548
37	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.006	0.1751	0.2539	1.000	2 x 1	N/A	1.500	3.939	Double	0.2539	11	0.2539	11	0.2539	11	0.2539	11	0.2539	11	0.2539	11	0.2539	11	0.2539	11	0.2539
38	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.010	0.1784	0.2504	1.000	2 x 1	N/A	1.500	4.034	Double	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504	11	0.2504
39	T300/N5208	37.5/50/12.5	0/45/90/45	0/45/90/45	1.005	0.1786	0.2518	1.000	2 x 1	N/A	1.500	3.991	Double	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518	11	0.2518
40	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.006	0.1787	0.2523	1.000	2 x 1	N/A	1.500	3.997	Double	0.2523	11	0.2523	11	0.2523	11	0.2523	11	0.2523	11	0.2523	11	0.2523	11	0.2523	11	0.2523
41	GI/T300/N5208	25/50/25	0/45/90/45	0/45/90/45	1.004	0.1804	0.2524	1.000	2 x 1	N/A	1.500	3.976	Double	0																

## Multiple Joints

P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Fastener Type	Test	Temp.	Moisture	Falling	Bearing	Bearing	Gross	Gross	Shearout	Gross	Remold	Reference	Remarks	Proportions
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Tension	RT	Unknown	5040	Unknown	55.0	Unknown	28.1	5.6	Unknown	Tens	Hart-Smith [1-17]	Ti Bolt ten. strength=160 ksi	Limit
2	Tension	RT	Unknown	5300	Unknown	56.8	Unknown	29.4	5.8	Unknown	Tens	Hart-Smith [1-17]		
3	Tension	RT	Unknown	5190	Unknown	56.2	Unknown	28.4	5.7	Unknown	Tens	Hart-Smith [1-17]		
4	Tension	RT	Unknown	5180	Unknown	55.2	Unknown	28.3	5.7	Unknown	Tens	Hart-Smith [1-17]		
5	Tension	RT	Unknown	6020	Unknown	66.1	Unknown	32.8	6.8	Unknown	Tens	Hart-Smith [1-17]		
6	Tension	RT	Unknown	6420	Unknown	66.2	Unknown	34.2	6.9	Unknown	Tens	Hart-Smith [1-17]		
7	Tension	RT	Unknown	6220	Unknown	69.1	Unknown	34.5	6.9	Unknown	Tens	Hart-Smith [1-17]		
8	Tension	RT	Unknown	5750	Unknown	82.5	Unknown	31.3	6.3	Unknown	Tens	Hart-Smith [1-17]		
9	Tension	RT	Unknown	6300	Unknown	74.5	Unknown	37.5	7.5	Unknown	Tens	Hart-Smith [1-17]		
10	Tension	RT	Unknown	6160	Unknown	72.0	Unknown	36.2	7.2	Unknown	Tens	Hart-Smith [1-17]		
11	Tension	RT	Unknown	6260	Unknown	73.4	Unknown	36.8	7.4	Unknown	Tens	Hart-Smith [1-17]		
12	Tension	RT	Unknown	5940	Unknown	82.1	Unknown	31.6	6.4	Unknown	Tens	Hart-Smith [1-17]		
13	Tension	RT	Unknown	6670	Unknown	74.2	Unknown	37.5	7.5	Unknown	Tens	Hart-Smith [1-17]		
14	Tension	RT	Unknown	7170	Unknown	79.5	Unknown	40.3	8.1	Unknown	Tens	Hart-Smith [1-17]		
15	Tension	RT	Unknown	6840	Unknown	77.0	Unknown	38.3	7.7	Unknown	Tab	Hart-Smith [1-17]		
16	Tension	RT	Unknown	7040	Unknown	79.1	Unknown	39.8	8.0	Unknown	Tab	Hart-Smith [1-17]		
17	Tension	RT	Unknown	8040	Unknown	91.2	Unknown	45.6	9.2	Unknown	Beas	Hart-Smith [1-17]		
18	Tension	RT	Unknown	7530	Unknown	86.5	Unknown	43.2	8.7	Unknown	Beas	Hart-Smith [1-17]		
19	Tension	RT	Unknown	7870	Unknown	87.8	Unknown	44.2	8.8	Unknown	Beas	Hart-Smith [1-17]		
20	Tension	RT	Unknown	7660	Unknown	86.9	Unknown	44.2	8.9	Unknown	Beas	Hart-Smith [1-17]		
21	Tension	RT	Unknown	7780	Unknown	90.9	Unknown	45.4	9.1	Unknown	Beas	Hart-Smith [1-17]		
22	Tension	RT	Unknown	7900	Unknown	90.5	Unknown	45.6	9.1	Unknown	Beas	Hart-Smith [1-17]		
23	Tension	RT	Unknown	7930	Unknown	91.2	Unknown	45.6	9.1	Unknown	Beas	Hart-Smith [1-17]		
24	Tension	RT	Unknown	8020	Unknown	92.9	Unknown	46.6	9.2	Unknown	Beas	Hart-Smith [1-17]		
25	Tension	RT	Unknown	8150	Unknown	85.7	Unknown	44.2	8.8	Unknown	Beas	Hart-Smith [1-17]		
26	Tension	RT	Unknown	8825	Unknown	93.0	Unknown	48.1	9.6	Unknown	Buckl	Hart-Smith [1-17]		
27	Tension	RT	Unknown	9190	Unknown	105.1	Unknown	53.0	10.7	Unknown	Buckl	Hart-Smith [1-17]		
28	Tension	RT	Unknown	8320	Unknown	90.0	Unknown	46.2	9.2	Unknown	Buckl	Hart-Smith [1-17]		
29	Tension	RT	Unknown	9295	Unknown	101.5	Unknown	50.4	10.4	Unknown	Bear	Hart-Smith [1-17]		
30	Tension	RT	Unknown	9400	Unknown	94.0	Unknown	51.8	10.4	Unknown	Bear	Hart-Smith [1-17]		
31	Tension	RT	Unknown	9980	Unknown	106.8	Unknown	53.9	10.8	Unknown	Buckl	Hart-Smith [1-17]		
32	Tension	RT	Unknown	9180	Unknown	99.9	Unknown	50.7	10.0	Unknown	Buckl	Hart-Smith [1-17]		
33	Tension	RT	Unknown	7290	Unknown	78.0	Unknown	39.3	7.8	Unknown	Bear	Hart-Smith [1-17]		
34	Tension	RT	Unknown	7680	Unknown	83.5	Unknown	41.7	8.6	Unknown	Bear	Hart-Smith [1-17]		
35	Tension	RT	Unknown	8320	Unknown	93.6	Unknown	47.5	9.5	Unknown	Buckl	Hart-Smith [1-17]		
36	Tension	RT	Unknown	7120	Unknown	79.2	Unknown	39.3	7.9	Unknown	Buckl	Hart-Smith [1-17]		
37	Tension	RT	Unknown	7095	Unknown	78.4	Unknown	39.3	7.9	Unknown	Buckl	Hart-Smith [1-17]		
38	Tension	RT	Unknown	7310	Unknown	81.1	Unknown	40.7	8.2	Unknown	Buckl	Hart-Smith [1-17]		
39	Tension	RT	Unknown	7370	Unknown	80.9	Unknown	40.7	8.1	Unknown	Buckl	Hart-Smith [1-17]		
40	Tension	RT	Unknown	6500	Unknown	74.3	Unknown	38.9	7.5	Unknown	Buckl	Hart-Smith [1-17]		
41	Tension	RT	Unknown	6560	Unknown	78.3	Unknown	38.9	7.9	Unknown	Buckl	Hart-Smith [1-17]		
42	Tension	RT	Unknown	7830	Unknown	86.7	Unknown	43.6	9.7	Unknown	Buckl	Hart-Smith [1-17]		
43	Tension	RT	Unknown	7695	Unknown	89.0	Unknown	44.8	8.7	Unknown	Buckl	Hart-Smith [1-17]		
44	Tension	RT	Unknown	7680	Unknown	88.0	Unknown	43.6	8.8	Unknown	Buckl	Hart-Smith [1-17]		
45	Tension	RT	Unknown	8200	Unknown	94.7	Unknown	47.7	9.5	Unknown	Buckl	Hart-Smith [1-17]		
46	Tension	RT	Unknown	7840	Unknown	90.4	Unknown	46.1	9.2	Unknown	Buckl	Hart-Smith [1-17]		
47	Tension	RT	0.00	10760	Unknown	100.7	Unknown	39.7	14.4	3136 Br. Sh	Buckl	Hart-Smith [1-17]		
48	Tension	RT	0.00	12500	Unknown	117.2	Unknown	39.0	16.7	3670 Br. Sh	Buckl	Hart-Smith [1-17]		
49	Tension	RT	0.00	13160	Unknown	123.9	Unknown	41.1	17.6	4000 Br. Sh	Buckl	Hart-Smith [1-17]		
50	Tension	RT	0.00	13140	Unknown	123.7	Unknown	41.0	17.6	4000 Br. Sh	Buckl	Hart-Smith [1-17]		

### Multiple Joints

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
36 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.2326	0.251	0.750/2 x 1	N/A	N/A	1.000	5.996	2.988	Double	0.249	ST3MA53-6-34 Bolt, Steel
37 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.2326	0.251	0.750/2 x 1	N/A	N/A	1.000	5.996	2.988	Double	0.249	ST3MA53-6-34 Bolt, Steel
38 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.2326	0.250	0.760/2 x 1	N/A	N/A	1.000	6.020	3.000	Double	0.249	ST3MA53-6-34 Bolt, Steel
39 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.2326	0.249	0.760/2 x 1	N/A	N/A	1.000	6.044	3.012	Double	0.249	ST3MA53-6-34 Bolt, Steel
40 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.2003	0.250	0.760/2 x 1	N/A	N/A	1.000	5.945	2.964	Double	0.249	ST3MA53-6-34 Bolt, Steel
41 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1932	0.251	0.760/2 x 1	N/A	N/A	1.000	5.988	2.988	Double	0.249	ST3MA53-6-34 Bolt, Steel
42 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.2012	0.252	0.760/2 x 1	N/A	N/A	1.000	5.944	2.976	Double	0.249	ST3MA53-6-34 Bolt, Steel
43 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.2294	0.253	0.760/2 x 1	N/A	N/A	1.000	5.945	2.964	Double	0.249	ST3MA53-6-34 Bolt, Steel
44 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.507	0.1966	0.249	0.760/2 x 1	N/A	N/A	1.000	6.052	3.012	Single	0.249	ST3MA53-6-34 Bolt, Steel
45 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.507	0.1966	0.249	0.760/2 x 1	N/A	N/A	1.000	6.052	3.012	Single	0.249	ST3MA53-6-34 Bolt, Steel
46 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.507	0.1966	0.249	0.760/2 x 1	N/A	N/A	1.000	6.052	3.012	Single	0.249	ST3MA53-6-34 Bolt, Steel
47 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.507	0.1966	0.250	0.760/2 x 1	N/A	N/A	1.000	6.028	3.000	Single	0.249	ST3MA53-6-34 Bolt, Steel
48 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.1984	0.252	0.750/2 x 1	N/A	N/A	1.000	5.968	2.976	Single	0.249	ST3MA53-6-34 Bolt, Steel
49 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.502	0.1962	0.252	0.750/2 x 1	N/A	N/A	1.000	5.960	2.976	Single	0.249	ST3MA53-6-34 Bolt, Steel
50 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.501	0.2123	0.251	0.750/2 x 1	N/A	N/A	1.000	5.980	2.988	Single	0.249	ST3MA53-6-34 Bolt, Steel
51 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.502	0.2126	0.250	0.750/2 x 1	N/A	N/A	1.000	6.008	3.000	Single	0.249	ST3MA53-6-34 Bolt, Steel
52 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.2187	0.250	0.750/2 x 1	N/A	N/A	1.000	5.949	2.964	Single	0.249	ST3MA53-6-34 Bolt, Steel
53 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.499	0.2084	0.251	0.750/2 x 1	N/A	N/A	1.000	5.972	2.988	Single	0.249	ST3MA53-6-34 Bolt, Steel
54 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.505	0.203	0.255	0.750/2 x 1	N/A	N/A	1.000	5.902	2.941	Single	0.249	ST3MA53-6-34 Bolt, Steel
55 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.502	0.2098	0.253	0.750/2 x 1	N/A	N/A	1.000	5.937	2.964	Single	0.249	ST3MA53-6-34 Bolt, Steel
56 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	3.007	0.1966	0.503	1.500/2 x 1	N/A	N/A	2.000	5.978	2.982	Double	0.249	ST3MA53-6-34 Bolt, Steel
57 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	3.037	0.1966	0.500	1.500/2 x 1	N/A	N/A	2.000	6.014	3.000	Double	0.500	ST3MA53-6-34 Bolt, Steel
58 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	3.003	0.1944	0.501	1.500/2 x 1	N/A	N/A	2.000	5.994	2.994	Double	0.500	ST3MA53-6-34 Bolt, Steel
59 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	3.032	0.1944	0.500	1.500/2 x 1	N/A	N/A	2.000	5.968	2.988	Double	0.500	ST3MA53-6-34 Bolt, Steel
60 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	2.259	0.2155	0.375	1.125/2 x 1	N/A	N/A	1.500	6.024	3.000	Double	0.375	ST3MA53-6-34 Bolt, Steel
61 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	2.259	0.2155	0.375	1.125/2 x 1	N/A	N/A	1.500	6.024	3.000	Double	0.375	ST3MA53-6-34 Bolt, Steel
62 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	2.251	0.214	0.375	1.125/2 x 1	N/A	N/A	1.500	6.003	3.000	Double	0.375	ST3MA53-6-34 Bolt, Steel
63 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	2.251	0.214	0.375	1.125/2 x 1	N/A	N/A	1.500	6.003	3.000	Double	0.375	ST3MA53-6-34 Bolt, Steel
64 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.131	0.2166	0.187	0.568/2 x 1	N/A	N/A	0.750	6.048	3.037	Double	0.187	AN3-20A Bolt
65 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.131	0.2166	0.188	0.568/2 x 1	N/A	N/A	0.750	6.018	3.021	Double	0.187	AN3-20A Bolt
66 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.131	0.2166	0.187	0.568/2 x 1	N/A	N/A	0.750	6.048	3.037	Double	0.187	AN3-20A Bolt
67 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.131	0.2166	0.187	0.568/2 x 1	N/A	N/A	0.750	6.048	3.037	Double	0.187	AN3-20A Bolt
68 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.1955	0.250	0.500/2 x 1	N/A	N/A	1.000	6.016	2.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
69 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.1955	0.249	0.500/2 x 1	N/A	N/A	1.000	6.040	2.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
70 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.1955	0.250	0.500/2 x 1	N/A	N/A	1.000	6.016	2.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
71 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.504	0.1955	0.250	0.500/2 x 1	N/A	N/A	1.000	6.016	2.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
72 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1958	0.255	0.500/2 x 1	N/A	N/A	1.000	5.894	3.022	Double	0.249	ST3MA53-4-26 Bolt, Steel
73 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1958	0.249	1.000/2 x 1	N/A	N/A	1.000	6.036	4.016	Double	0.249	ST3MA53-4-26 Bolt, Steel
74 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1958	0.250	1.000/2 x 1	N/A	N/A	1.000	6.012	4.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
75 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1958	0.250	1.000/2 x 1	N/A	N/A	1.000	6.036	4.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
76 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.1966	0.249	0.75/2 x 1	N/A	N/A	1.000	6.036	1.506	Double	0.249	ST3MA53-4-26 Bolt, Steel
77 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.193	0.251	0.75/2 x 1	N/A	N/A	1.000	5.988	1.494	Double	0.249	ST3MA53-4-26 Bolt, Steel
78 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.196	0.250	0.75/2 x 1	N/A	N/A	1.000	6.036	1.506	Double	0.249	ST3MA53-4-26 Bolt, Steel
79 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.503	0.2241	0.251	0.750/2 x 1	N/A	N/A	1.000	6.036	1.506	Double	0.249	ST3MA53-4-26 Bolt, Steel
80 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.000	2.988	Double	0.249	ST3MA53-4-26 Bolt, Steel
81 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.000	2.988	Double	0.249	ST3MA53-4-26 Bolt, Steel
82 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
83 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
84 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
85 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
86 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
87 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
88 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
89 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
90 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
91 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
92 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
93 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
94 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
95 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
96 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
97 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
98 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
99 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
100 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-26 Bolt, Steel
101 AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/18	1.506	0.2241	0.250	0.750/2 x 1	N/A	N/A	0.750	6.024	3.000	Double	0.249	ST3MA53-4-2

P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
56	25 Tension RT	RT	0.00	13395	Unknown	114.7	Unknown	38.3	16.5	3635 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
57	25 Tension RT	RT	0.00	13380	Unknown	114.6	Unknown	38.2	16.4	3725 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
58	25 Tension RT	RT	0.00	15300	Unknown	131.6	Unknown	43.7	18.6	4290 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
59	25 Tension RT	RT	0.00	14380	Unknown	124.1	Unknown	41.1	17.7	4080 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
60	0 Tension	250	0.77	9730	Unknown	96.0	Unknown	32.3	13.9	2715 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
61	0 Tension	250	0.72	8970	Unknown	92.5	Unknown	30.9	13.3	2670 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
62	0 Tension	250	0.80	8400	Unknown	82.8	Unknown	27.8	11.9	2550 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
63	0 Tension	250	0.97	10400	Unknown	89.6	Unknown	30.1	13.0	2970 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
64	50 Tension RT	RT	0.00	10100	Unknown	103.2	Unknown	34.1	14.7	2940 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
65	50 Tension RT	RT	0.00	11650	Unknown	119.0	Unknown	39.3	16.9	3465 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
66	50 Tension RT	RT	0.00	11840	Unknown	118.9	Unknown	39.3	16.9	3350 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
67	50 Tension RT	RT	0.00	13170	Unknown	134.0	Unknown	44.5	19.1	3655 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
68	50 Tension RT	RT	0.75	12360	Unknown	123.6	Unknown	41.4	17.8	3770 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
69	50 Tension RT	RT	0.74	11050	Unknown	111.7	Unknown	37.5	16.1	3265 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
70	50 Tension RT	RT	0.84	12900	Unknown	121.0	Unknown	40.5	17.4	3880 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
71	50 Tension RT	RT	0.86	13030	Unknown	122.6	Unknown	40.8	17.5	3805 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
72	50 Tension RT	250	0.91	10290	Unknown	93.0	Unknown	31.3	13.4	2950 Bear		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
73	50 Tension RT	250	0.86	10780	Unknown	102.6	Unknown	34.3	14.7	3325 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
74	50 Tension RT	250	0.88	10820	Unknown	104.5	Unknown	35.4	15.2	3267 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
75	50 Tension RT	250	0.81	9740	Unknown	91.7	Unknown	30.9	13.3	2840 Br, Sh		Garbo et al. [1-38]	Steel bolt, Gr/Ep specimen	
76	50 Tension RT	RT	0.00	22500	Unknown	112.6	Unknown	37.7	16.2	3215 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
77	50 Tension RT	RT	0.00	22700	Unknown	114.3	Unknown	38.0	16.3	3290 Bear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
78	50 Tension RT	RT	0.00	17800	Unknown	91.4	Unknown	30.5	13.1	2615 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
79	50 Tension RT	RT	0.00	22800	Unknown	117.8	Unknown	39.2	16.8	3330 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
80	50 Tension RT	RT	0.00	16000	Unknown	111.4	Unknown	37.0	15.9	3220 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
81	50 Tension RT	RT	0.00	18900	Unknown	116.9	Unknown	38.8	16.7	3585 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
82	160 Tension RT	RT	0.00	19750	Unknown	123.1	Unknown	41.0	17.6	3485 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
83	160 Tension RT	RT	0.00	20925	Unknown	130.4	Unknown	43.4	18.6	3550 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
84	50 Tension RT	RT	0.00	9500	Unknown	117.3	Unknown	38.6	16.6	3740 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
85	50 Tension RT	RT	0.00	9460	Unknown	116.2	Unknown	38.6	16.6	3705 Bear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
86	50 Tension RT	RT	0.00	9520	Unknown	117.5	Unknown	38.9	16.7	3555 Bear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
87	50 Tension RT	RT	0.00	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Bolt Sh		Garbo et al. [1-38]	Early bolt failure in shear!	
88	50 Tension RT	RT	0.00	10220	Unknown	104.6	Unknown	34.6	17.4	3045 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
89	50 Tension RT	RT	0.00	10800	Unknown	110.9	Unknown	36.7	18.4	3205 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
90	50 Tension RT	RT	0.00	11270	Unknown	115.3	Unknown	38.3	19.2	3420 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
91	50 Tension RT	RT	0.00	11060	Unknown	113.1	Unknown	37.6	18.6	3380 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
92	50 Tension RT	RT	0.00	14420	Unknown	144.4	Unknown	49.0	18.4	4355 Bear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
93	50 Tension RT	RT	0.00	13200	Unknown	136.4	Unknown	44.9	16.9	4115 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
94	50 Tension RT	RT	0.00	14000	Unknown	143.0	Unknown	47.6	17.8	4420 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
95	50 Tension RT	RT	0.00	13380	Unknown	136.7	Unknown	45.5	17.1	4120 Sh, Br		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
96	50 Tension RT	RT	0.00	8780	Unknown	96.8	Unknown	29.7	16.3	2820 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
97	50 Tension RT	RT	0.00	9520	Unknown	96.8	Unknown	32.3	17.7	2870 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
98	50 Tension RT	RT	0.00	9390	Unknown	95.8	Unknown	31.9	17.4	2855 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
99	50 Tension RT	RT	0.00	9040	Unknown	92.6	Unknown	30.7	16.6	2880 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
100	50 Tension RT	RT	0.00	12680	Unknown	112.7	Unknown	37.6	18.9	3445 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
101	50 Tension RT	RT	0.00	13800	Unknown	123.2	Unknown	40.9	20.5	3850 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
102	50 Tension RT	RT	0.00	13780	Unknown	122.8	Unknown	40.8	20.5	3680 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
103	50 Tension RT	RT	0.00	14800	Unknown	130.3	Unknown	43.3	21.7	4050 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
104	50 Tension RT	RT	0.00	12180	Unknown	113.4	Unknown	37.9	22.9	3400 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
105	50 Tension RT	RT	0.00	12440	Unknown	116.9	Unknown	38.7	23.4	3480 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
106	50 Tension RT	RT	0.00	12460	Unknown	116.9	Unknown	38.6	23.4	3485 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
107	50 Tension RT	RT	0.00	12360	Unknown	116.9	Unknown	38.4	23.2	3600 Ten-Civ		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
108	50 Tension RT	250	0.93	11480	Unknown	96.2	Unknown	33.0	9.9	3270 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
109	50 Tension RT	250	0.85	11280	Unknown	107.6	Unknown	36.1	10.8	3125 Shear		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
110	50 Tension RT	250	0.81	8480	Unknown	82.0	Unknown	27.6	8.3	2450 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	
111	50 Tension RT	250	0.78	8480	Unknown	84.9	Unknown	28.6	8.6	2520 Br, Sh		Garbo et al. [1-38]	Bushing bet. bolt & specimen	

### Multiple Joins

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
112AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.503	0.199	0.252	1.500/2 x 1	N/A		1.000	5.964	5.952	Double	0.249	ST3M453-4-26 Bolt, Steel
113AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.507	0.1968	0.253	1.500/2 x 1	N/A		1.000	5.957	5.929	Double	0.249	ST3M453-4-26 Bolt, Steel
114AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.2158	0.251	1.500/2 x 1	N/A		1.000	5.980	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
115AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.505	0.2172	0.252	1.500/2 x 1	N/A		1.000	5.972	5.952	Double	0.249	ST3M453-4-26 Bolt, Steel
116AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.511	0.2307	0.250	1.500/2 x 1	N/A		1.000	6.044	6.000	Double	0.249	ST3M453-4-26 Bolt, Steel
117AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.2129	0.249	1.500/2 x 1	N/A		1.000	6.028	6.024	Double	0.249	ST3M453-4-26 Bolt, Steel
118AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1968	0.251	1.500/2 x 1	N/A		1.000	5.980	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
119AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.504	0.2151	0.250	1.500/2 x 1	N/A		1.000	6.016	6.000	Double	0.249	ST3M453-4-26 Bolt, Steel
120AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.503	0.2085	0.252	1.500/2 x 1	N/A		0.750	5.994	5.952	Double	0.249	ST3M453-4-26 Bolt, Steel
121AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.506	0.2295	0.252	1.500/2 x 1	N/A		0.750	5.976	5.952	Double	0.249	ST3M453-4-26 Bolt, Steel
122AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.505	0.2108	0.251	1.500/2 x 1	N/A		0.750	5.996	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
123AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.505	0.2084	0.253	1.500/2 x 1	N/A		0.750	5.949	5.928	Double	0.249	ST3M453-4-26 Bolt, Steel
124AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.507	0.2115	0.251	1.500/2 x 1	N/A		0.500	6.004	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
125AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.503	0.2115	0.251	1.500/2 x 1	N/A		0.500	5.988	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
126AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.506	0.2228	0.252	1.500/2 x 1	N/A		0.500	5.972	5.952	Double	0.249	ST3M453-4-26 Bolt, Steel
127AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.515	0.2295	0.251	1.500/2 x 1	N/A		0.500	6.036	5.976	Double	0.249	ST3M453-4-26 Bolt, Steel
128AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.504	0.211	0.252	0.750/2 x 1	N/A		1.000	3.984	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
129AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.004	0.211	0.250	0.750/2 x 1	N/A		1.000	4.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
130AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.004	0.211	0.250	0.750/2 x 1	N/A		1.000	4.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
131AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.253	0.2158	0.250	0.750/2 x 1	N/A		1.000	5.012	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
132AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.253	0.2158	0.250	0.750/2 x 1	N/A		1.000	5.012	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
133AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.253	0.2158	0.250	0.750/2 x 1	N/A		1.000	5.012	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
134AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.253	0.2158	0.250	0.750/2 x 1	N/A		1.000	5.012	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
135AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.253	0.2158	0.250	0.750/2 x 1	N/A		1.000	5.012	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
136AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2114	0.252	0.750/2 x 1	N/A		1.000	7.952	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
137AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2114	0.250	0.750/2 x 1	N/A		1.000	8.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
138AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2114	0.250	0.750/2 x 1	N/A		1.000	8.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
139AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2114	0.250	0.750/2 x 1	N/A		1.000	8.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
140AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2114	0.250	0.750/2 x 1	N/A		1.000	8.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
141AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.005	0.2159	0.253	2.000/2 x 1	N/A		1.000	7.905	7.905	Double	0.249	ST3M453-4-26 Bolt, Steel
142AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.005	0.2159	0.253	2.000/2 x 1	N/A		1.000	7.925	7.905	Double	0.249	ST3M453-4-26 Bolt, Steel
143AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.004	0.2164	0.251	2.000/2 x 1	N/A		1.000	7.984	7.984	Double	0.249	ST3M453-4-26 Bolt, Steel
144AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	2.006	0.2130	0.252	2.000/2 x 1	N/A		1.000	7.960	7.937	Double	0.249	ST3M453-4-26 Bolt, Steel
145AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.251	0.1951	0.251	1.250/2 x 1	N/A		1.000	4.984	4.980	Double	0.249	ST3M453-4-26 Bolt, Steel
146AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.255	0.2053	0.252	1.250/2 x 1	N/A		1.000	4.980	4.960	Double	0.249	ST3M453-4-26 Bolt, Steel
147AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.250	0.1974	0.252	1.250/2 x 1	N/A		1.000	4.960	4.960	Double	0.249	ST3M453-4-26 Bolt, Steel
148AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.254	0.2073	0.249	1.250/2 x 1	N/A		1.000	5.036	5.020	Double	0.249	ST3M453-4-26 Bolt, Steel
149AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.001	0.1947	0.2500	1.000/2 x 1	N/A		1.000	4.004	4.000	Double	0.249	ST3M453-4-26 Bolt, Steel
150AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.005	0.1988	0.2520	1.000/2 x 1	N/A		1.000	3.988	3.968	Double	0.249	ST3M453-4-26 Bolt, Steel
151AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	0.998	0.1923	0.2510	1.000/2 x 1	N/A		1.000	3.978	3.994	Double	0.249	ST3M453-4-26 Bolt, Steel
152AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.004	0.2004	0.2500	1.000/2 x 1	N/A		1.000	4.016	4.016	Double	0.249	ST3M453-4-26 Bolt, Steel
153AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.502	0.2082	0.2500	0.750/2 x 1	N/A		1.000	6.008	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
154AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.502	0.2082	0.2500	0.750/2 x 1	N/A		1.000	6.008	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
155AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.502	0.2082	0.2500	0.750/2 x 1	N/A		1.000	6.044	3.012	Double	0.249	ST3M453-4-26 Bolt, Steel
156AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.502	0.2082	0.2500	0.750/2 x 1	N/A		1.000	5.921	2.953	Double	0.249	ST3M453-4-26 Bolt, Steel
157AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.504	0.2071	0.2540	0.750/2 x 1	N/A		1.000	5.949	2.964	Double	0.249	ST3M453-4-26 Bolt, Steel
158AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.430	0.2043	0.2500	0.750/2 x 1	N/A		1.000	5.960	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
159AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.498	0.2034	0.2510	0.750/2 x 1	N/A		1.000	5.960	2.998	Double	0.249	ST3M453-4-26 Bolt, Steel
160AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.500	0.1993	0.2500	0.750/2 x 1	N/A		1.000	5.960	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
161AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.500	0.205	0.2540	0.750/2 x 1	N/A		1.000	5.908	2.953	Double	0.249	ST3M453-4-26 Bolt, Steel
162AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.504	0.2108	0.2510	0.750/2 x 1	N/A		1.000	5.992	2.988	Double	0.249	ST3M453-4-26 Bolt, Steel
163AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	5.956	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
164AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
165AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
166AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
167AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
168AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
169AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
170AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
171AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
172AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
173AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
174AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
175AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
176AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
177AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/6	1.501	0.1867	0.2570	0.750/2 x 1	N/A		1.000	6.004	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
112	50 Tension	250	0.76	10480	Unknown	104.5	Unknown	35.0	10.5	3105	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
113	50 Tension	250	0.76	11040	Unknown	110.9	Unknown	37.2	11.2	3420	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
114	50 Tension	250	0.89	10260	Unknown	94.7	Unknown	31.7	9.5	3090	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
115	50 Tension	250	0.90	10000	Unknown	91.4	Unknown	30.6	9.2	2860	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
116	50 Tension	250	0.92	9120	Unknown	79.1	Unknown	26.2	7.9	2380	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
117	50 Tension	250	0.85	9100	Unknown	85.0	Unknown	26.2	8.5	2630	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
118	50 Tension	250	0.78	7370	Unknown	74.6	Unknown	24.9	7.5	2230	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
119	50 Tension	250	0.89	6980	Unknown	64.9	Unknown	21.6	6.6	2150	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
120	50 Tension	250	0.79	10330	Unknown	96.3	Unknown	33.3	11.1	3105	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
121	50 Tension	250	0.94	12500	Unknown	108.1	Unknown	38.2	12.1	3575	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
122	50 Tension	250	0.86	11700	Unknown	110.6	Unknown	36.9	12.3	3372	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
123	50 Tension	250	0.80	8480	Unknown	81.2	Unknown	27.3	9.1	2562	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
124	50 Tension	250	0.84	9330	Unknown	87.9	Unknown	29.3	11.0	2750	Br. Sh		Garbo et al. (1-38)	No bushing bet. bolt & spec.	
125	50 Tension	250	0.87	8920	Unknown	84.0	Unknown	28.1	10.5	2665	Br. Sh		Garbo et al. (1-38)	No bushing bet. bolt & spec.	
126	50 Tension	250	0.95	7560	Unknown	67.3	Unknown	22.5	8.5	2260	Br. Sh		Garbo et al. (1-38)	No bushing bet. bolt & spec.	
127	50 Tension	250	0.97	8800	Unknown	76.7	Unknown	25.4	9.8	2400	Br. Sh		Garbo et al. (1-38)	No bushing bet. bolt & spec.	
128	50 Tension	RT	0.00	11430	Unknown	107.5	Unknown	84.0	15.5	5050	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
129	50 Tension	RT	0.00	10720	Unknown	101.6	Unknown	50.8	14.5	4700	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
130	50 Tension	RT	0.00	9790	Unknown	92.8	Unknown	46.2	13.3	4500	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
131	50 Tension	RT	0.00	10100	Unknown	95.7	Unknown	47.7	13.7	4570	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
132	50 Tension	RT	0.00	12600	Unknown	118.6	Unknown	47.3	16.9	4335	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
133	50 Tension	RT	0.00	12760	Unknown	119.4	Unknown	47.6	17.1	4515	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
134	50 Tension	RT	0.00	12600	Unknown	116.8	Unknown	46.6	16.7	4475	Tens		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
135	50 Tension	RT	0.00	13200	Unknown	123.9	Unknown	31.2	17.8	2875	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
136	50 Tension	RT	0.00	13040	Unknown	120.4	Unknown	30.8	17.6	3085	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
137	50 Tension	RT	0.00	13700	Unknown	129.6	Unknown	32.3	18.5	2015	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
138	50 Tension	RT	0.00	13300	Unknown	126.8	Unknown	31.4	18.0	2860	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
139	50 Tension	250	0.79	10440	Unknown	96.3	Unknown	24.4	8.1	2340	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
140	50 Tension	250	0.96	10820	Unknown	99.0	Unknown	25.0	8.4	2400	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
141	50 Tension	250	0.76	9020	Unknown	73.8	Unknown	18.5	6.2	1850	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
142	50 Tension	250	0.86	11560	Unknown	107.2	Unknown	26.9	9.0	2680	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
143	50 Tension	250	0.82	11840	Unknown	104.5	Unknown	41.9	11.7	3690	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
144	50 Tension	250	0.76	10120	Unknown	101.7	Unknown	41.0	11.4	3600	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
145	50 Tension	250	0.82	9850	Unknown	97.8	Unknown	38.9	10.8	3820	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
146	50 Tension	250	0.86	10100	Unknown	99.4	Unknown	49.7	12.4	4215	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
147	50 Tension	250	0.90	11040	Unknown	110.2	Unknown	56.3	13.9	4760	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
148	50 Tension	250	0.74	8840	Unknown	91.6	Unknown	46.1	11.5	3890	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
149	50 Tension	250	0.82	9480	Unknown	94.8	Unknown	47.1	11.8	4330	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
150	50 Tension	RT	0.00	12840	Unknown	122.9	Unknown	41.1	17.8	3780	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
151	50 Tension	RT	0.00	13600	Unknown	130.6	Unknown	43.5	18.7	4055	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
152	50 Tension	RT	0.00	13450	Unknown	129.2	Unknown	43.5	18.6	4040	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
153	50 Tension	RT	0.00	13780	Unknown	132.4	Unknown	44.1	18.9	4080	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
154	50 Tension	RT	0.00	12900	Unknown	121.3	Unknown	40.1	17.3	3715	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
155	50 Tension	RT	0.00	12800	Unknown	123.6	Unknown	41.7	17.9	3800	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
156	50 Tension	RT	0.00	12800	Unknown	122.1	Unknown	41.1	17.7	3785	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
157	50 Tension	RT	0.00	14100	Unknown	136.0	Unknown	46.3	19.7	4265	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
158	50 Tension	RT	0.00	11200	Unknown	109.7	Unknown	36.8	16.7	3330	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
159	50 Tension	250	0.78	10700	Unknown	107.4	Unknown	35.8	16.3	3325	Beal		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
160	50 Tension	250	0.78	9000	Unknown	96.4	Unknown	29.3	12.6	2650	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
161	50 Tension	250	0.87	8880	Unknown	93.6	Unknown	31.2	13.4	3000	Br. Sh		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
162	50 Tension	RT	0.00	8040	Unknown	85.4	Unknown	28.7	12.3	1930	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
163	50 Tension	RT	0.00	8370	Unknown	89.7	Unknown	29.9	12.8	2045	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
164	50 Tension	RT	0.00	8360	Unknown	89.4	Unknown	29.8	12.8	2255	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	
165	50 Tension	RT	0.00	9040	Unknown	98.8	Unknown	32.3	13.8	2175	Shear		Garbo et al. (1-38)	Bushing bet. bolt & specimen	

## Multiple Joints

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
118	AS1/3501-6	70/20/10	[45/0/-45/0]/3/90/0/3]	1.504	0.1867	0.2510	0.750/2 x 1	N/A	1.000	1.000	5.992	2.988	Double	0.249	ST3M453-4-26 Bolt, Steel
119	AS1/3501-6	70/20/10	[45/0/-45/0]/3/90/0/3]	1.496	0.1913	0.2520	0.750/2 x 1	N/A	1.000	1.000	5.937	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
120	AS1/3501-6	70/20/10	[45/0/-45/0]/3/90/0/3]	1.504	0.1865	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
121	AS1/3501-6	70/20/10	[45/0/-45/0]/3/90/0/3]	1.505	0.1863	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.020	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
122	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.507	0.2142	0.2510	0.750/2 x 1	N/A	1.000	1.000	6.004	2.988	Double	0.249	ST3M453-4-26 Bolt, Steel
123	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.507	0.2142	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.026	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
124	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.507	0.2142	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.028	3.000	Double	0.249	ST3M453-4-26 Bolt, Steel
125	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.504	0.2169	0.2540	0.750/2 x 1	N/A	1.000	1.000	5.921	2.953	Double	0.249	ST3M453-4-26 Bolt, Steel
126	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.505	0.212	0.2510	0.750/2 x 1	N/A	1.000	1.000	5.964	2.968	Double	0.249	ST3M453-4-26 Bolt, Steel
127	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.503	0.2165	0.2520	0.750/2 x 1	N/A	1.000	1.000	5.964	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
128	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	1.505	0.2148	0.2520	0.750/2 x 1	N/A	1.000	1.000	5.972	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
129	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.507	0.2074	0.2540	0.750/2 x 2	1.000	1.000	4.931	2.950	Single	0.249	ST3M453-4-14 Bolt, Steel	
130	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.510	0.1971	0.2520	0.750/2 x 2	1.000	1.000	4.962	2.966	Single	0.249	ST3M453-4-14 Bolt, Steel	
131	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.503	0.2169	0.2518	0.750/2 x 2	1.000	1.000	4.970	2.979	Single	0.249	ST3M453-4-14 Bolt, Steel	
132	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.504	0.2181	0.2521	0.750/2 x 2	1.000	1.000	4.967	2.975	Single	0.249	ST3M453-4-14 Bolt, Steel	
133	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.502	0.2112	0.2520	0.750/2 x 2	1.000	1.000	4.947	2.966	Single	0.249	ST3M453-4-14 Bolt, Steel	
134	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.500	0.1944	0.2523	0.750/2 x 2	1.000	1.000	4.954	2.973	Single	0.249	ST3M453-4-14 Bolt, Steel	
135	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.510	0.1987	0.2514	0.750/2 x 2	1.000	1.000	4.992	2.983	Single	0.249	ST3M453-4-14 Bolt, Steel	
136	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.503	0.1946	0.2514	0.750/2 x 2	1.000	1.000	4.978	2.983	Single	0.249	ST3M453-4-14 Bolt, Steel	
137	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.507	0.2033	0.2536	0.750/2 x 2	1.000	1.000	4.943	2.957	Double	0.249	ST3M453-4-6 Bolt, Steel	
138	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.498	0.2116	0.2520	0.750/2 x 2	1.000	1.000	4.956	2.976	Double	0.249	ST3M453-4-6 Bolt, Steel	
139	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.507	0.2107	0.2514	0.750/2 x 2	1.000	1.000	4.936	2.983	Double	0.249	ST3M453-4-6 Bolt, Steel	
140	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.505	0.2033	0.2520	0.750/2 x 2	1.000	1.000	4.970	2.978	Double	0.249	ST3M453-4-6 Bolt, Steel	
141	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.502	0.2137	0.2514	0.750/2 x 2	1.000	1.000	4.976	2.983	Double	0.249	ST3M453-4-6 Bolt, Steel	
142	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.506	0.2041	0.2524	0.750/2 x 2	1.000	1.000	4.964	2.971	Double	0.249	ST3M453-4-6 Bolt, Steel	
143	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.505	0.2126	0.2522	0.750/2 x 2	1.000	1.000	4.966	2.974	Double	0.249	ST3M453-4-6 Bolt, Steel	
144	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.497	0.1946	0.2514	0.750/2 x 2	1.000	1.000	4.966	2.983	Double	0.249	ST3M453-4-6 Bolt, Steel	
145	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.508	0.1944	0.2527	0.750/2 x 2	1.000	1.000	4.962	2.968	Double	0.249	ST3M453-4-23 Bolt, Steel	
146	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.502	0.1997	0.2518	0.750/2 x 2	1.000	1.000	4.968	2.979	Double	0.249	ST3M453-4-23 Bolt, Steel	
147	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.503	0.1918	0.2522	0.750/2 x 2	1.000	1.000	4.962	2.974	Double	0.249	ST3M453-4-23 Bolt, Steel	
148	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.504	0.2192	0.2519	0.750/2 x 2	1.000	1.000	4.970	2.977	Double	0.249	ST3M453-4-23 Bolt, Steel	
149	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.500	0.2158	0.2537	0.750/2 x 2	1.000	1.000	4.927	2.958	Double	0.249	ST3M453-4-23 Bolt, Steel	
150	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.502	0.2000	0.2527	0.750/2 x 2	1.000	1.000	4.951	2.968	Double	0.249	ST3M453-4-23 Bolt, Steel	
151	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.504	0.2140	0.2523	0.750/2 x 2	1.000	1.000	4.962	2.973	Double	0.249	ST3M453-4-23 Bolt, Steel	
152	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.508	0.2119	0.2519	0.750/2 x 2	1.000	1.000	4.978	2.977	Double	0.249	ST3M453-4-23 Bolt, Steel	
153	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.500	0.1970	0.2531	0.750/2 x 2	1.000	1.000	4.959	2.963	Double	0.249	ST3M453-4-23 Bolt, Steel	
154	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.500	0.1944	0.2519	0.750/2 x 2	1.000	1.000	4.962	2.977	Double	0.249	ST3M453-4-23 Bolt, Steel	
155	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.503	0.2123	0.2515	0.750/2 x 2	1.000	1.000	4.976	2.982	Double	0.249	ST3M453-4-23 Bolt, Steel	
156	AS1/3501-6	50/40/10	[45/0/-45/0]/90/0/-45/0/+45/0/1	2.511	0.2056	0.2524	0.750/2 x 2	1.000	1.000	4.954	2.971	Double	0.249	ST3M453-4-23 Bolt, Steel	
157	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.506	0.2127	0.2532	0.750/2 x 2	1.000	1.000	4.920	2.974	Single	0.249	ST3M453-4-14 Bolt, Steel	
158	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.507	0.2103	0.2518	0.750/2 x 2	1.000	1.000	4.978	2.979	Single	0.249	ST3M453-4-14 Bolt, Steel	
159	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.500	0.2175	0.2528	0.750/2 x 2	1.000	1.000	4.945	2.967	Single	0.249	ST3M453-4-14 Bolt, Steel	
160	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.509	0.2235	0.2518	0.750/2 x 2	1.000	1.000	4.970	2.979	Single	0.249	ST3M453-4-14 Bolt, Steel	
161	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.504	0.2203	0.2530	0.750/2 x 2	1.000	1.000	4.931	2.954	Single	0.249	ST3M453-4-14 Bolt, Steel	
162	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.498	0.2173	0.2518	0.750/2 x 2	1.000	1.000	4.960	2.978	Single	0.249	ST3M453-4-14 Bolt, Steel	
163	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.500	0.2178	0.2537	0.750/2 x 2	1.000	1.000	4.927	2.956	Single	0.249	ST3M453-4-14 Bolt, Steel	
164	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.504	0.2152	0.2527	0.750/2 x 2	1.000	1.000	4.954	2.966	Single	0.249	ST3M453-4-14 Bolt, Steel	
165	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.512	0.2084	0.2515	0.750/2 x 2	1.000	1.000	4.974	2.982	Double	0.249	ST3M453-4-14 Bolt, Steel	
166	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.511	0.2094	0.2537	0.750/2 x 2	1.000	1.000	4.929	2.956	Double	0.249	ST3M453-4-14 Bolt, Steel	
167	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.510	0.2056	0.2518	0.750/2 x 2	1.000	1.000	4.964	2.978	Double	0.249	ST3M453-4-14 Bolt, Steel	
168	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.504	0.2070	0.2540	0.750/2 x 2	1.000	1.000	4.929	2.953	Double	0.249	ST3M453-4-14 Bolt, Steel	
169	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.507	0.2103	0.2517	0.750/2 x 2	1.000	1.000	4.960	2.978	Double	0.249	ST3M453-4-14 Bolt, Steel	
170	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.506	0.2077	0.2510	0.750/2 x 2	1.000	1.000	4.974	2.977	Double	0.249	ST3M453-4-14 Bolt, Steel	
171	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.512	0.2047	0.2536	0.750/2 x 2	1.000	1.000	4.953	2.957	Double	0.249	ST3M453-4-14 Bolt, Steel	
172	AS1/3501-6	30/60/10	[45/0/-45/0]/45/90/-45/0/+45/1	2.492	0.1998	0.2526	0.750/2 x 2	1.000	1.000	4.933	2.969	Double	0.249	ST3M453-4-14 Bolt, Steel	

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
168	50 Tension	250	0.73	6140	Unknown	65.5	Unknown	21.9	9.4	1415	Br, Sh	Garbo et. al. (1-38)	Rushing bet. bolt & specimen		
169	50 Tension	250	0.71	6460	Unknown	67.0	Unknown	22.6	9.6	1460	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
170	50 Tension	250	0.89	4820	Unknown	57.7	Unknown	17.2	7.4	1190	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
171	50 Tension	250	0.73	5550	Unknown	58.9	Unknown	19.6	8.4	1300	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
172	50 Tension RT	250	0.00	13000	Unknown	120.9	Unknown	40.3	17.3	5310	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
173	50 Tension RT	250	0.00	13050	Unknown	121.8	Unknown	40.4	17.4	5300	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
174	50 Tension RT	250	0.00	13840	Unknown	127.4	Unknown	42.3	18.2	5660	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
175	50 Tension RT	250	0.00	13380	Unknown	124.9	Unknown	41.4	17.8	5600	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
176	50 Tension	250	0.93	11860	Unknown	107.6	Unknown	36.4	15.6	5440	Br	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
177	50 Tension	250	0.87	11480	Unknown	107.7	Unknown	36.9	15.4	4850	Br	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
178	50 Tension	250	0.90	9800	Unknown	89.8	Unknown	30.1	12.9	4280	Br	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
179	50 Tension	250	0.92	9680	Unknown	89.4	Unknown	29.9	12.9	4250	Br	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
180	50 Tension RT	250	0.00	24700	Unknown	117.1	Unknown	47.5	17.0	4430	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & spec.		
181	50 Tension RT	250	0.00	25350	Unknown	127.1	Unknown	51.2	18.4	4120	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
182	50 Tension RT	250	0.00	24900	Unknown	114.0	Unknown	45.9	16.4	4390	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
183	50 Tension RT	250	0.00	24900	Unknown	113.2	Unknown	45.6	16.3	4465	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
184	50 Tension	250	0.87	19000	Unknown	88.9	Unknown	36.0	12.9	3240	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
185	50 Tension	250	0.73	19000	Unknown	96.8	Unknown	39.1	14.0	3480	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
186	50 Tension	250	0.78	20950	Unknown	104.8	Unknown	42.0	15.1	3570	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
187	50 Tension	250	0.74	18650	Unknown	96.3	Unknown	38.3	13.7	3220	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
188	50 Tension RT	250	0.00	26150	Unknown	126.8	Unknown	51.3	18.4	4580	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
189	50 Tension RT	250	0.00	25200	Unknown	118.1	Unknown	47.7	17.0	4200	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
190	50 Tension RT	250	0.00	24850	Unknown	117.3	Unknown	47.0	16.8	4140	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
191	50 Tension RT	250	0.00	26250	Unknown	128.1	Unknown	51.5	18.4	4460	Tens	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
192	50 Tension	250	0.89	23200	Unknown	108.0	Unknown	43.4	15.5	4040	Shear	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
193	50 Tension	250	0.82	21900	Unknown	108.3	Unknown	42.8	15.3	3880	Ten-clev	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
194	50 Tension	250	0.87	20200	Unknown	94.2	Unknown	37.9	13.6	3620	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
195	50 Tension	250	0.78	20750	Unknown	108.0	Unknown	42.7	15.2	3870	Br, Sh	Garbo et. al. (1-38)	Bushing bet. bolt & specimen		
196	50 Tension RT	250	0.00	26600	Unknown	135.4	Unknown	54.8	19.5	4500	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
197	50 Tension RT	250	0.00	26250	Unknown	130.5	Unknown	52.5	18.8	4510	Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
198	50 Tension RT	250	0.00	27050	Unknown	139.8	Unknown	56.3	20.1	4720	Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
199	50 Tension RT	250	0.00	26500	Unknown	120.0	Unknown	48.3	17.3	4690	Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
200	50 Tension	250	0.90	24750	Unknown	113.0	Unknown	45.9	16.4	4450	Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
201	50 Tension	250	0.78	23550	Unknown	118.5	Unknown	47.1	16.8	4340	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
202	50 Tension	250	0.89	22700	Unknown	106.1	Unknown	42.4	15.2	4180	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
203	50 Tension	250	0.84	22700	Unknown	108.3	Unknown	42.7	15.3	3920	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
204	50 Tension	250	0.78	23000	Unknown	115.3	Unknown	46.7	16.7	4510	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
205	50 Tension	250	0.73	23150	Unknown	118.2	Unknown	47.8	17.0	4386	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
206	50 Tension	250	0.88	25500	Unknown	119.4	Unknown	48.0	17.2	5085	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
207	50 Tension	250	0.85	22900	Unknown	110.3	Unknown	44.5	15.9	4360	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
208	50 Tension RT	250	0.00	22800	Unknown	106.3	Unknown	42.8	15.3	6510	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
209	50 Tension RT	250	0.00	22800	Unknown	106.7	Unknown	42.9	15.4	6530	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
210	50 Tension RT	250	0.00	23550	Unknown	107.1	Unknown	43.3	15.5	5440	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
211	50 Tension RT	250	0.00	22850	Unknown	102.0	Unknown	41.0	14.7	5300	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
212	50 Tension	250	0.91	19400	Unknown	86.7	Unknown	36.2	12.6	4825	Br	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
213	50 Tension	250	0.92	20300	Unknown	92.8	Unknown	37.4	13.3	5400	Br	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
214	50 Tension	250	0.81	21375	Unknown	97.6	Unknown	39.3	14.0	5150	Br, Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
215	50 Tension	250	0.86	21225	Unknown	97.6	Unknown	39.4	14.1	5080	Br, Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
216	50 Tension RT	250	0.00	21100	Unknown	101.6	Unknown	40.9	14.6	3315	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
217	50 Tension RT	250	0.00	21800	Unknown	101.6	Unknown	41.2	14.7	3580	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
218	50 Tension RT	250	0.00	21050	Unknown	101.7	Unknown	40.8	14.6	3260	Br, Ten-clev	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
219	50 Tension RT	250	0.00	21300	Unknown	101.3	Unknown	41.1	14.7	3260	Br, Sh	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
220	50 Tension RT	250	0.00	20900	Unknown	96.7	Unknown	39.6	14.2	4820	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
221	50 Tension RT	250	0.00	20700	Unknown	98.9	Unknown	39.8	14.2	4690	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
222	50 Tension RT	250	0.00	20450	Unknown	98.5	Unknown	39.8	14.3	4480	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		
223	50 Tension RT	250	0.00	22500	Unknown	111.5	Unknown	45.2	16.1	4990	Tens	Garbo et. al. (1-38)	No bushing bet. bolt & spec.		

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P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
224	50 Comp	RT	0.00	11350	Unknown	101.3	Unknown	33.8	14.6	3260	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
225	50 Comp	RT	0.00	11500	Unknown	114.3	Unknown	38.4	16.5	3455	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
226	50 Comp	RT	0.00	12150	Unknown	120.7	Unknown	40.9	17.6	3375	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
227	50 Comp	RT	0.00	12800	Unknown	122.7	Unknown	40.4	17.4	3717	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
228	50 Comp	RT	0.74	11500	Unknown	117.3	Unknown	38.1	16.8	3205	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
229	50 Comp	RT	0.74	10600	Unknown	106.2	Unknown	35.7	15.4	3135	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
230	50 Comp	RT	0.77	12700	Unknown	127.9	Unknown	43.0	18.5	3505	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
231	50 Comp	RT	0.82	11800	Unknown	109.9	Unknown	36.9	15.9	3190	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
232	50 Comp	RT	0.86	11780	Unknown	105.7	Unknown	35.3	15.2	3230	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
233	50 Comp	RT	0.84	10500	Unknown	97.4	Unknown	32.4	14.0	2935	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
234	50 Comp	RT	0.87	10200	Unknown	94.9	Unknown	31.9	13.7	2805	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
235	50 Comp	RT	0.89	10400	Unknown	94.7	Unknown	32.4	13.9	2820	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
236	50 Comp	RT	0.00	14100	Unknown	136.7	Unknown	48.4	19.9	4860	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
237	50 Comp	RT	0.00	13800	Unknown	126.5	Unknown	42.3	18.1	4445	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
238	50 Comp	RT	0.00	14680	Unknown	154.3	Unknown	44.7	22.2	4780	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
239	50 Comp	RT	0.00	14080	Unknown	133.3	Unknown	44.7	19.2	5280	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
240	50 Comp	RT	0.89	14000	Unknown	128.5	Unknown	43.1	18.5	4440	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
241	50 Comp	RT	0.86	14800	Unknown	143.6	Unknown	47.5	20.4	4840	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
242	50 Comp	RT	0.95	16140	Unknown	139.3	Unknown	48.8	20.1	5025	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
243	50 Comp	RT	0.82	14300	Unknown	137.7	Unknown	45.8	19.7	4960	Br, Ten-clev	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
244	50 Comp	RT	0.81	11080	Unknown	106.7	Unknown	35.8	15.4	3760	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
245	50 Comp	RT	0.89	11200	Unknown	100.3	Unknown	33.6	14.4	3500	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
246	50 Comp	RT	0.88	11720	Unknown	110.0	Unknown	36.7	16.7	4332	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
247	50 Comp	RT	0.90	11620	Unknown	111.2	Unknown	36.9	15.9	3568	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
248	50 Comp	RT	0.00	11440	Unknown	122.1	Unknown	41.2	17.7	3090	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
249	50 Comp	RT	0.00	10950	Unknown	117.9	Unknown	39.5	16.9	2800	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
250	50 Comp	RT	0.00	11880	Unknown	123.9	Unknown	41.9	18.0	2810	Br, Sh bet. hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
251	50 Comp	RT	0.00	11700	Unknown	122.1	Unknown	41.1	17.6	3000	Br, Sh bet. hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
252	50 Comp	RT	0.73	7580	Unknown	79.0	Unknown	26.7	11.5	2240	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
253	50 Comp	RT	0.75	7960	Unknown	82.7	Unknown	27.8	11.9	2185	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
254	50 Comp	RT	0.76	7500	Unknown	78.0	Unknown	26.3	11.2	2104	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
255	50 Comp	RT	0.74	7820	Unknown	81.4	Unknown	27.3	11.7	2016	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
256	50 Comp	RT	0.00	13410	Unknown	123.6	Unknown	41.4	17.8	6550	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
257	50 Comp	RT	0.00	12800	Unknown	118.7	Unknown	39.8	17.0	5520	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
258	50 Comp	RT	0.00	13380	Unknown	121.9	Unknown	40.8	17.5	6375	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
259	50 Comp	RT	0.00	13000	Unknown	122.1	Unknown	40.7	17.5	6375	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
260	50 Comp	RT	0.88	11000	Unknown	99.3	Unknown	33.5	14.4	4185	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
261	50 Comp	RT	0.82	10700	Unknown	99.4	Unknown	33.2	14.2	4995	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
262	50 Comp	RT	0.92	10000	Unknown	92.0	Unknown	31.0	13.3	5500	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
263	50 Comp	RT	0.89	9440	Unknown	87.3	Unknown	29.2	12.8	5080	Com. outside hole	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
264	50 Comp	RT	0.00	17200	Unknown	85.8	Unknown	34.8	12.4	3305	Bear	Garbo et al. [1-38]	Bushing bet. bolt & specimen	
265	50 Comp	RT	0.00	17300	Unknown	83.1	Unknown	33.4	11.9	3400	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
266	70 Comp	RT	0.00	22650	Unknown	105.9	Unknown	42.5	15.2	3225	Br, Ten-clev	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
267	70 Comp	RT	0.00	33260	Unknown	157.7	Unknown	63.3	22.7	6885	Br, Ten-clev	Garbo et al. [1-38]	Early bolt failure in shear	
268	0 Comp	RT	0.00	21360	Unknown	100.4	Unknown	40.3	14.4	6025	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
269	0 Comp	RT	0.00	23000	Unknown	105.7	Unknown	43.0	15.4	6025	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
270	70 Comp	RT	0.00	29300	Unknown	140.5	Unknown	58.9	20.4	4160	Com. outside hole	Garbo et al. [1-38]	Early bolt failure in shear	
271	70 Comp	RT	0.00	29360	Unknown	139.2	Unknown	56.1	20.1	2820	Bear	Garbo et al. [1-38]	Early bolt failure in shear	
272	0 Comp	RT	0.00	15800	Unknown	78.8	Unknown	31.0	11.1	4160	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
273	0 Comp	RT	0.00	23160	Unknown	111.8	Unknown	45.2	16.1	4320	Com. outside hole	Garbo et al. [1-38]	Early bolt failure in shear	
274	70 Comp	RT	0.00	31400	Unknown	149.0	Unknown	59.9	21.5	3720	Com. outside hole	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
275	70 Comp	RT	0.00	28700	Unknown	136.9	Unknown	55.1	19.7	4125	Com. outside hole	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
276	0 Comp	RT	0.00	18080	Unknown	77.7	Unknown	31.2	11.2	4125	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
277	0 Comp	RT	0.00	16480	Unknown	78.9	Unknown	31.8	11.4	4125	Bear	Garbo et al. [1-38]	No bushing bet. bolt & spec.	
278	70 Comp	RT	0.00	28200	Unknown	137.7	Unknown	55.1	19.8	Br Co. outside hole	Garbo et al. [1-38]	Early bolt failure in shear		
279	0 Comp	RT	0.00	23480	Unknown	113.4	Unknown	45.5	16.3	Br Co. outside hole	Garbo et al. [1-38]	Early bolt failure in shear		

## Multiple Joints

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
280	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.511	0.2234	0.252	0.750/2 x 1	N/A	1.000	5.996	2.976	Double	0.249	ST3M453-4-26	Bolt, Steel
281	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.511	0.2234	0.254	0.750/2 x 1	N/A	1.000	5.949	2.963	Double	0.249	ST3M453-4-26	Bolt, Steel
282	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.511	0.2234	0.253	0.750/2 x 1	N/A	1.000	5.972	2.964	Double	0.249	ST3M453-4-26	Bolt, Steel
283	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.511	0.2234	0.254	0.750/2 x 1	N/A	1.000	5.949	2.963	Double	0.249	ST3M453-4-26	Bolt, Steel
284	AS1/3501-6	50/60/10	45/0/-/45/0/45/0/90/-/45/0/45/6	1.507	0.2066	0.253	0.750/2 x 1	N/A	1.000	5.957	2.964	Double	0.249	ST3M453-4-26	Bolt, Steel
285	AS1/3501-6	50/60/10	45/0/-/45/0/45/0/90/-/45/0/45/6	1.507	0.2066	0.252	0.750/2 x 1	N/A	1.000	5.990	2.976	Double	0.249	ST3M453-4-26	Bolt, Steel
286	AS1/3501-6	50/60/10	45/0/-/45/0/45/0/90/-/45/0/45/6	1.507	0.2066	0.253	0.750/2 x 1	N/A	1.000	5.957	2.964	Double	0.249	ST3M453-4-26	Bolt, Steel
287	AS1/3501-6	50/60/10	45/0/-/45/0/45/0/90/-/45/0/45/6	1.507	0.2066	0.254	0.750/2 x 1	N/A	1.000	5.933	2.953	Double	0.249	ST3M453-4-26	Bolt, Steel
288	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.509	0.2220	0.254	0.750/2 x 1	N/A	1.000	5.941	2.953	Double	0.249	ST3M453-4-26	Bolt, Steel
289	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.509	0.2220	0.250	0.750/2 x 1	N/A	1.000	6.036	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
290	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.509	0.2220	0.250	0.750/2 x 1	N/A	1.000	6.036	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
291	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.507	0.2226	0.251	0.750/2 x 1	N/A	1.000	6.004	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
292	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.507	0.2226	0.249	0.750/2 x 1	N/A	1.000	6.052	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
293	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.507	0.2226	0.250	0.750/2 x 1	N/A	1.000	6.029	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
294	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.507	0.2226	0.251	0.750/2 x 1	N/A	1.000	6.004	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
295	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.507	0.2226	0.253	0.750/2 x 1	N/A	1.000	5.957	2.964	Double	0.249	ST3M453-4-26	Bolt, Steel
296	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.509	0.2135	0.252	0.750/2 x 1	N/A	1.000	5.988	2.978	Double	0.249	ST3M453-4-26	Bolt, Steel
297	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.509	0.2262	0.254	0.750/2 x 1	N/A	1.000	5.941	2.953	Double	0.249	ST3M453-4-26	Bolt, Steel
298	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2155	0.252	0.750/2 x 1	N/A	1.000	5.984	2.976	Double	0.249	ST3M453-4-26	Bolt, Steel
299	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2159	0.250	0.750/2 x 1	N/A	1.000	6.024	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
300	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2159	0.250	0.750/2 x 1	N/A	1.000	6.024	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
301	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2159	0.250	0.750/2 x 1	N/A	1.000	6.024	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
302	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2159	0.250	0.750/2 x 1	N/A	1.000	6.024	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
303	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2159	0.250	0.750/2 x 1	N/A	1.000	6.024	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
304	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2231	0.251	0.750/2 x 1	N/A	1.000	5.972	2.981	Double	0.249	ST3M453-4-26	Bolt, Steel
305	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2231	0.251	0.750/2 x 1	N/A	1.000	5.972	2.981	Double	0.249	ST3M453-4-26	Bolt, Steel
306	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2231	0.251	0.750/2 x 1	N/A	1.000	5.972	2.981	Double	0.249	ST3M453-4-26	Bolt, Steel
307	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2231	0.251	0.750/2 x 1	N/A	1.000	5.972	2.981	Double	0.249	ST3M453-4-26	Bolt, Steel
308	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.513	0.2229	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
309	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.513	0.2229	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
310	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.513	0.2229	0.250	0.750/2 x 1	N/A	1.000	6.052	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
311	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.513	0.2229	0.250	0.750/2 x 1	N/A	1.000	6.052	3.000	Double	0.249	ST3M453-4-26	Bolt, Steel
312	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2199	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
313	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2199	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
314	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2199	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
315	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2199	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
316	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.510	0.2199	0.251	0.750/2 x 1	N/A	1.000	6.016	2.988	Double	0.249	ST3M453-4-26	Bolt, Steel
317	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
318	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
319	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
320	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
321	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
322	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
323	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.508	0.2201	0.248	0.750/2 x 1	N/A	1.000	6.048	3.012	Double	0.249	ST3M453-4-26	Bolt, Steel
324	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
325	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
326	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
327	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
328	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
329	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
330	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
331	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
332	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
333	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
334	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
335	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
336	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
337	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
338	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
339	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
340	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
341	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
342	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1.512	0.2148	0.245	0.750/2 x 1	N/A	1.000	6.171	3.061	Double	0.249	ST3M453-4-26	Bolt, Steel
343	AS1/3501-6	50/40/10	45/0/-/45/0/90/0/45/0/-/45/0/6	1											

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
2280	50 Tens	RT	RT	0.00	14100	Unknown	125.2	Unknown	41.8	18.0	4030	Ten-clev	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2281	50 Tens	RT	RT	0.00	13900	Unknown	122.5	Unknown	41.2	17.8	4080	Ten-clev	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2282	50 Tens	RT	RT	0.00	14100	Unknown	124.7	Unknown	41.8	18.0	4015	Ten-clev	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2283	50 Tens	RT	RT	0.00	13875	Unknown	122.3	Unknown	41.1	17.7	3930	Ten	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2284	50 Tens	RT	RT	0.00	14200	Unknown	135.8	Unknown	45.6	19.6	5810	Ten	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2285	50 Tens	RT	RT	0.00	12850	Unknown	125.4	Unknown	41.3	17.8	5210	Ten	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2286	50 Tens	RT	RT	0.00	12300	Unknown	117.7	Unknown	39.5	17.0	4870	Ten	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2287	50 Tens	RT	RT	0.00	13000	Unknown	123.9	Unknown	41.8	18.0	5120	Ten	Garbo et al. [1-38]	"Out-of-round test, with bushing	
2288	50 Tens	RT	RT	0.00	13710	Unknown	121.6	Unknown	40.9	17.6	3875	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2289	50 Tens	RT	RT	0.00	13820	Unknown	124.5	Unknown	41.3	17.8	4045	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2290	50 Tens	RT	RT	0.00	12300	Unknown	110.8	Unknown	36.7	15.8	3815	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2291	50 Tens	RT	RT	0.00	12750	Unknown	114.9	Unknown	38.1	16.4	3640	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2292	50 Tens	RT	RT	0.00	13800	Unknown	123.5	Unknown	41.1	17.7	3975	Br, Ten-clev	Garbo et al. [1-38]	"Severe delam. test; with bushing	
2293	50 Tens	RT	RT	0.00	13060	Unknown	117.8	Unknown	38.9	16.8	3855	Br, Ten-clev	Garbo et al. [1-38]	"Severe delam. test; with bushing	
2294	50 Tens	RT	RT	0.00	11100	Unknown	99.7	Unknown	33.1	14.2	3158	Br, Ten-clev, Sh	Garbo et al. [1-38]	"Severe delam. test; with bushing	
2295	50 Tens	RT	RT	0.00	11825	Unknown	105.8	Unknown	35.3	15.2	3480	Br, Sh	Garbo et al. [1-38]	"Severe delam. test; with bushing	
2296	50 Tens	RT	RT	0.00	13220	Unknown	119.5	Unknown	40.1	17.3	3875	Br, Sh	Garbo et al. [1-38]	"Severe porosity, with bushing	
2297	50 Tens	RT	RT	0.00	13810	Unknown	128.3	Unknown	42.9	18.5	4080	Br, Sh	Garbo et al. [1-38]	"Severe porosity, with bushing	
2298	50 Tens	RT	RT	0.00	13220	Unknown	115.0	Unknown	38.7	16.7	3885	Br, Sh	Garbo et al. [1-38]	"Severe porosity, with bushing	
2299	50 Tens	RT	RT	0.00	13440	Unknown	123.7	Unknown	41.4	17.8	3920	Br, Sh	Garbo et al. [1-38]	"Severe porosity, with bushing	
2300	50 Tens	RT	RT	0.00	11540	Unknown	106.9	Unknown	35.5	15.3	3330	Sh, Br	Garbo et al. [1-38]	"Cak seating 80% of spe. thk.; Bu.	
2301	50 Tens	RT	RT	0.00	11060	Unknown	102.5	Unknown	34.0	14.6	3225	Sh, Br	Garbo et al. [1-38]	"Cak seating 80% of spe. thk.; Bu.	
2302	50 Tens	RT	RT	0.00	10940	Unknown	101.3	Unknown	33.6	14.5	3275	Sh, Br	Garbo et al. [1-38]	"Cak seating 80% of spe. thk.; Bu.	
2303	50 Tens	RT	RT	0.00	11275	Unknown	104.4	Unknown	34.7	14.9	3120	Sh, Br	Garbo et al. [1-38]	"Cak seating 80% of spe. thk.; Bu.	
2304	50 Tens	RT	RT	0.00	7830	Unknown	66.5	Unknown	23.2	10.0	2285	Sh, Br	Garbo et al. [1-38]	"Cak seating 100% of sp. thk.; Bu.	
2305	50 Tens	RT	RT	0.00	8920	Unknown	79.8	Unknown	26.5	11.4	2730	Sh, Br	Garbo et al. [1-38]	"Cak seating 100% of sp. thk.; Bu.	
2306	50 Tens	RT	RT	0.00	8980	Unknown	80.2	Unknown	26.7	11.5	2575	Sh, Br	Garbo et al. [1-38]	"Cak seating 100% of sp. thk.; Bu.	
2307	50 Tens	RT	RT	0.00	9300	Unknown	83.0	Unknown	27.8	11.9	2570	Sh, Br	Garbo et al. [1-38]	"Cak seating 100% of sp. thk.; Bu.	
2308	50 Tens	RT	RT	0.00	13430	Unknown	120.0	Unknown	39.8	17.2	3980	Br, Sh	Garbo et al. [1-38]	"Tilted cak away bear. surface; Bu.	
2309	50 Tens	RT	RT	0.00	13850	Unknown	124.3	Unknown	41.1	17.8	4210	Br, Sh	Garbo et al. [1-38]	"Tilted cak away bear. surface; Bu.	
2310	50 Tens	RT	RT	0.00	13400	Unknown	120.2	Unknown	39.7	17.2	3880	Br, Sh	Garbo et al. [1-38]	"Tilted cak away bear. surface; Bu.	
2311	50 Tens	RT	RT	0.00	13600	Unknown	122.0	Unknown	40.3	17.4	3560	Br, Sh	Garbo et al. [1-38]	"Tilted cak away bear. surface; Bu.	
2312	50 Tens	RT	RT	0.00	10340	Unknown	93.7	Unknown	31.1	13.4	2715	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2313	50 Tens	RT	RT	0.00	11320	Unknown	103.0	Unknown	34.1	14.7	3080	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2314	50 Tens	RT	RT	0.00	11380	Unknown	103.8	Unknown	34.3	14.8	3080	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2315	50 Tens	RT	RT	0.00	10875	Unknown	98.9	Unknown	32.8	14.1	3250	Br, Sh	Garbo et al. [1-38]	"Moderate delam. test; with bush.	
2316	50 Tens	RT	RT	0.00	13710	Unknown	125.8	Unknown	41.4	17.8	3945	Br, Sh	Garbo et al. [1-38]	"Interference fit, with bushing	
2317	50 Tens	RT	RT	0.00	14140	Unknown	129.0	Unknown	42.7	18.4	4065	Br, Sh	Garbo et al. [1-38]	"Interference fit, with bushing	
2318	50 Tens	RT	RT	0.00	13600	Unknown	124.1	Unknown	41.0	17.7	3965	Br, Sh	Garbo et al. [1-38]	"Interference fit, no bushing	
2319	50 Tens	RT	RT	0.00	13320	Unknown	123.0	Unknown	40.2	17.9	4035	Br, Sh	Garbo et al. [1-38]	"Interference fit, no bushing	
2320	50 Tens	RT	RT	0.00	13980	Unknown	124.9	Unknown	42.2	18.1	4050	Br, Sh	Garbo et al. [1-38]	"Interference fit, with bushing	
2321	50 Tens	RT	RT	0.00	13580	Unknown	121.8	Unknown	41.0	17.6	3905	Br, Sh	Garbo et al. [1-38]	"Interference fit, with bushing	
2322	50 Tens	RT	RT	0.00	13700	Unknown	126.3	Unknown	41.4	17.8	4130	Br, Sh	Garbo et al. [1-38]	"Interference fit, no bushing	
2323	50 Tens	RT	RT	0.00	12950	Unknown	121.4	Unknown	39.1	16.8	4015	Br, Sh	Garbo et al. [1-38]	"Interference fit, no bushing	
2324	50 Tens	RT	250	0.91	11520	Unknown	106.5	Unknown	35.5	15.3	3570	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2325	50 Tens	RT	250	0.88	11280	Unknown	105.9	Unknown	35.8	15.4	2535	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2326	50 Tens	RT	250	0.96	11860	Unknown	108.0	Unknown	36.3	18.3	3680	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2327	50 Tens	RT	250	0.92	10930	Unknown	100.8	Unknown	36.1	15.8	3330	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2328	50 Tens	RT	250	0.82	11160	Unknown	113.2	Unknown	36.2	15.7	3415	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2329	50 Tens	RT	250	0.92	10810	Unknown	102.3	Unknown	33.0	14.2	3185	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2330	50 Tens	RT	250	0.86	11700	Unknown	108.2	Unknown	34.9	15.0	3805	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2331	50 Tens	RT	250	0.86	10420	Unknown	109.1	Unknown	33.7	14.6	3205	Br, Ten-clev	Garbo et al. [1-38]	"Interference fit, no bushing	
2332	50 Tens	RT	RT	0.00	13680	Unknown	134.1	Unknown	44.3	19.1	5500	Tens	Garbo et al. [1-38]	"Interference fit, with bushing	
2333	50 Tens	RT	RT	0.00	13180	Unknown	126.2	Unknown	42.7	18.4	5345	Tens	Garbo et al. [1-38]	"Interference fit, with bushing	
2334	50 Tens	RT	RT	0.00	13700	Unknown	124.1	Unknown	44.4	19.1	5710	Tens	Garbo et al. [1-38]	"Interference fit, no bushing	
2335	50 Tens	RT	RT	0.00	12680	Unknown	126.8	Unknown	41.1	17.7	5300	Tens	Garbo et al. [1-38]	"Interference fit, no bushing	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
336	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.504	0.2028	0.2445	0.750/2 x 1	N/A	1.000	1.000	6.151	3.067	Double	0.249	ST3M453-4-26 Bolt, Steel
337	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.504	0.2028	0.2449	0.750/2 x 1	N/A	1.000	1.000	6.141	3.062	Double	0.249	ST3M453-4-26 Bolt, Steel
338	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.504	0.2028	0.2478	0.750/2 x 1	N/A	1.000	1.000	6.059	3.027	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
339	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.504	0.2028	0.2420	0.750/2 x 1	N/A	1.000	1.000	6.215	3.099	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
340	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.506	0.2045	0.2454	0.750/2 x 1	N/A	1.000	1.000	6.137	3.056	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
341	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.505	0.2051	0.2451	0.750/2 x 1	N/A	1.000	1.000	6.140	3.060	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
342	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.505	0.2118	0.2434	0.750/2 x 1	N/A	1.000	1.000	6.133	3.056	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
343	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.505	0.2118	0.2434	0.750/2 x 1	N/A	1.000	1.000	6.024	3.055	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
344	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.479	0.1938	0.2455	0.750/2 x 1	N/A	1.000	1.000	6.221	3.098	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
345	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.506	0.2059	0.2421	0.750/2 x 1	N/A	1.000	1.000	6.074	3.095	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
346	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.470	0.2026	0.2420	0.750/2 x 1	N/A	1.000	1.000	6.211	3.095	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
347	AS1/3501-6	30/60/10	45/0/-45/0/45/90/-45/0/+45/0	1.505	0.2131	0.2423	0.750/2 x 1	N/A	1.000	1.000	6.218	3.097	Double	0.249	ST3M750Y4-6 Pin-Rivet Threaded
348	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.509	0.2195	0.2528	0.750/2 x 1	N/A	1.000	1.000	5.959	2.967	Double	0.249	ST3M453-4-26 Bolt, Pro-H, Steel
349	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.509	0.2195	0.2502	0.750/2 x 1	N/A	1.000	1.000	6.031	2.998	Double	0.249	ST3M453-4-26 Bolt, Pro-H, Steel
350	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.509	0.2195	0.2502	0.750/2 x 1	N/A	1.000	1.000	6.031	2.998	Double	0.249	ST3M453-4-26 Bolt, Pro-H, Steel
351	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.509	0.2195	0.2501	0.750/2 x 1	N/A	1.000	1.000	6.034	2.999	Double	0.249	ST3M453-4-26 Bolt, Pro-H, Steel
352	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2108	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Pro-H, Steel
353	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2108	0.2502	0.750/2 x 1	N/A	1.000	1.000	6.011	2.998	Double	0.249	ST3M453-4-26 Bolt, Cat-H, Steel
354	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2108	0.2503	0.750/2 x 1	N/A	1.000	1.000	6.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Cat-H, Steel
355	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2108	0.2500	0.750/2 x 1	N/A	1.000	1.000	6.016	3.000	Double	0.249	ST3M453-4-26 Bolt, Cat-H, Steel
356	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.503	0.2108	0.2533	0.750/2 x 1	N/A	1.000	1.000	5.934	2.961	Double	0.249	ST3M453-4-26 Bolt, Steel
357	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.501	0.2181	0.2537	0.750/2 x 1	N/A	1.000	1.000	5.916	2.956	Double	0.249	ST3M453-4-26 Bolt, Steel
358	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.505	0.2200	0.2533	0.750/2 x 1	N/A	1.000	1.000	5.942	2.961	Double	0.249	ST3M453-4-26 Bolt, Steel
359	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.506	0.2059	0.2527	0.750/2 x 1	N/A	1.000	1.000	6.017	2.975	Double	0.249	ST3M453-4-26 Bolt, Steel
360	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.517	0.2234	0.2521	0.750/2 x 1	N/A	1.000	1.000	5.960	2.968	Double	0.249	ST3M453-4-26 Bolt, Steel
361	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.508	0.2015	0.2509	0.750/2 x 1	N/A	1.000	1.000	6.017	2.975	Double	0.249	ST3M453-4-26 Bolt, Steel
362	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.491	0.2135	0.2505	0.750/2 x 1	N/A	1.000	1.000	6.010	2.989	Double	0.249	ST3M453-4-26 Bolt, Steel
363	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2037	0.2522	0.750/2 x 1	N/A	1.000	1.000	5.952	2.994	Double	0.249	ST3M453-4-26 Bolt, Steel
364	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2165	0.2531	0.750/2 x 1	N/A	1.000	1.000	5.964	2.974	Double	0.249	ST3M453-4-26 Bolt, Steel
365	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.492	0.2242	0.2532	0.750/2 x 1	N/A	1.000	1.000	5.942	2.963	Double	0.249	ST3M453-4-26 Bolt, Steel
366	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.513	0.2223	0.2540	0.750/2 x 1	N/A	1.000	1.000	5.893	2.962	Double	0.249	ST3M453-4-26 Bolt, Steel
367	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.501	0.2197	0.2536	0.750/2 x 1	N/A	1.000	1.000	5.957	2.953	Double	0.249	ST3M453-4-26 Bolt, Steel
368	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.502	0.2156	0.2507	0.750/2 x 1	N/A	1.000	1.000	5.919	2.957	Double	0.249	ST3M453-4-26 Bolt, Steel
369	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.511	0.2118	0.2505	0.750/2 x 1	N/A	1.000	1.000	5.991	2.992	Double	0.249	ST3M453-4-26 Bolt, Steel
370	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.506	0.2043	0.2504	0.750/2 x 1	N/A	1.000	1.000	6.032	2.994	Double	0.249	ST3M453-4-26 Bolt, Steel
371	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.505	0.2183	0.2515	0.750/2 x 1	N/A	1.000	1.000	6.014	2.995	Double	0.249	ST3M453-4-26 Bolt, Steel
372	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.505	0.2142	0.2535	0.750/2 x 1	N/A	1.000	1.000	5.984	2.982	Double	0.249	ST3M453-4-26 Bolt, Steel
373	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.510	0.2159	0.2507	0.750/2 x 1	N/A	1.000	1.000	5.937	2.959	Double	0.249	ST3M453-4-26 Bolt, Steel
374	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.510	0.2281	0.2511	0.750/2 x 1	N/A	1.000	1.000	6.014	2.987	Double	0.249	ST3M453-4-26 Bolt, Steel
375	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.508	0.2187	0.2532	0.750/2 x 1	N/A	1.000	1.000	5.977	2.973	Double	0.249	ST3M453-4-26 Bolt, Steel
376	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.524	0.2116	0.2529	0.750/2 x 1	N/A	1.000	1.000	5.947	2.966	Double	0.249	ST3M453-4-26 Bolt, Steel
377	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.502	0.2145	0.2549	0.750/2 x 1	N/A	1.000	1.000	5.993	2.982	Double	0.249	ST3M453-4-26 Bolt, Steel
378	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2048	0.2553	0.750/2 x 1	N/A	1.000	1.000	5.891	2.934	Double	0.249	ST3M453-4-26 Bolt, Steel
379	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.526	0.2131	0.2533	0.750/2 x 1	N/A	1.000	1.000	5.938	2.981	Double	0.249	ST3M453-4-26 Bolt, Steel
380	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.505	0.2263	0.2538	0.750/2 x 1	N/A	1.000	1.000	5.930	2.955	Double	0.249	ST3M453-4-26 Bolt, Steel
381	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.507	0.2217	0.2516	0.750/2 x 1	N/A	1.000	1.000	5.990	2.981	Double	0.249	ST3M453-4-26 Bolt, Steel
382	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.507	0.2190	0.2503	0.750/2 x 1	N/A	1.000	1.000	6.008	2.983	Double	0.249	ST3M453-4-26 Bolt, Steel
383	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.509	0.2172	0.2519	0.750/2 x 1	N/A	1.000	1.000	5.990	2.977	Double	0.249	ST3M453-4-26 Bolt, Steel
384	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2184	0.2518	0.750/2 x 1	N/A	1.000	1.000	5.973	2.979	Double	0.249	ST3M453-4-26 Bolt, Steel
385	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.502	0.2184	0.2506	0.750/2 x 1	N/A	1.000	1.000	5.923	2.957	Double	0.249	ST3M453-4-26 Bolt, Steel
386	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2175	0.2526	0.750/2 x 1	N/A	1.000	1.000	5.984	2.976	Double	0.249	ST3M453-4-26 Bolt, Steel
387	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.506	0.2191	0.2536	0.750/2 x 1	N/A	1.000	1.000	5.957	2.967	Double	0.249	ST3M453-4-26 Bolt, Steel
388	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.503	0.2137	0.2518	0.750/2 x 1	N/A	1.000	1.000	5.969	2.979	Double	0.249	ST3M453-4-26 Bolt, Steel
389	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.504	0.2088	0.2516	0.750/2 x 1	N/A	1.000	1.000	5.978	2.981	Double	0.249	ST3M453-4-26 Bolt, Steel
390	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.505	0.2082	0.2502	0.750/2 x 1	N/A	1.000	1.000	6.006	2.993	Double	0.249	ST3M453-4-26 Bolt, Steel
391	AS1/3501-6	50/40/10	45/0/-45/0/90/0/45/0/-45/0/+45/0	1.501	0.2176	0.2505	0.750/2 x 1	N/A	1.000	1.000	5.920	2.993	Double	0.249	ST3M453-4-26 Bolt, Steel

P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
336	50 Tens	RT	0.00	12680	Unknown	127.9	Unknown	41.6	17.9	5430 Tens		Garbo et al. [1-38]	*Interference fit, with bushing	
337	50 Tens	RT	0.00	12520	Unknown	126.0	Unknown	41.0	17.6	5380 Tens		Garbo et al. [1-38]	*Interference fit, with bushing	
338	50 Tens	RT	0.00	12810	Unknown	127.5	Unknown	42.0	18.0	5630 Tens		Garbo et al. [1-38]	*Interference fit, no bushing	
339	50 Tens	RT	0.00	12240	Unknown	124.7	Unknown	40.1	17.2	Gage failed		Garbo et al. [1-38]	*Interference fit, no bushing	
340	50 Tens	250	0.84	10820	Unknown	107.8	Unknown	35.1	15.1	4680 Bear		Garbo et al. [1-38]	*Interference fit, no bushing	
341	50 Tens	250	0.83	10840	Unknown	107.8	Unknown	35.1	15.1	4355 Bear		Garbo et al. [1-38]	*Interference fit, no bushing	
342	50 Tens	250	0.89	11880	Unknown	115.2	Unknown	37.6	16.2	6050 Br, Sh		Garbo et al. [1-38]	*Interference fit, no bushing	
343	50 Tens	250	0.81	11150	Unknown	117.2	Unknown	38.9	16.4	6205 Br, Tens		Garbo et al. [1-38]	*Interference fit, no bushing	
344	50 Tens	250	0.85	10580	Unknown	105.9	Unknown	34.1	14.7	41295 Bear		Garbo et al. [1-38]	*Interference fit, no bushing	
345	50 Tens	250	0.88	10980	Unknown	112.0	Unknown	36.9	15.5	5100 Br, Sh		Garbo et al. [1-38]	*Interference fit, no bushing	
346	50 Tens	250	0.88	10920	Unknown	105.7	Unknown	34.0	14.6	4390 Br, Sh		Garbo et al. [1-38]	*Interference fit, no bushing	
347	50 Tens	250	0.89	11000	Unknown	107.5	Unknown	34.6	14.9	4695 Br, Sh		Garbo et al. [1-38]	*Interference fit, no bushing	
348	50 Tens	RT	0.00	13450	Unknown	121.2	Unknown	40.8	17.5	4080 Br, Sh		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
349	50 Tens	RT	0.00	14640	Unknown	133.3	Unknown	44.2	19.1	4245 Br, Ten-clev		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
350	50 Tens	RT	0.00	13700	Unknown	124.7	Unknown	41.4	17.8	3935 Br, Ten-clev		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
351	50 Tens	RT	0.00	12000	Unknown	109.3	Unknown	36.2	15.6	3420 Br, Sh		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
352	50 Tens	RT	0.00	14000	Unknown	132.8	Unknown	44.2	19.0	4230 Br, Sh		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
353	50 Tens	RT	0.00	13550	Unknown	128.5	Unknown	42.7	18.4	3925 Br, Sh		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
354	50 Tens	RT	0.00	13380	Unknown	129.7	Unknown	42.9	18.4	4030 Br, Sh		Garbo et al. [1-38]	*Bolt test & remv. 100 times, Bush	
355	50 Comp	RT	0.00	13800	Unknown	126.7	Unknown	42.9	18.4	4850 Bear		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
356	50 Comp	RT	0.00	14700	Unknown	137.7	Unknown	46.4	19.9	4540 Br, Comp, outside hole		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
357	50 Comp	RT	0.94	15000	Unknown	136.8	Unknown	46.2	19.8	4030 Bear		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
358	50 Comp	RT	0.95	13500	Unknown	121.1	Unknown	40.8	17.6	4030 Bear		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
359	50 Comp	RT	0.96	14120	Unknown	135.7	Unknown	45.6	19.5	4360 Bear		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
360	50 Comp	RT	0.99	14300	Unknown	127.0	Unknown	42.2	18.3	4960 Bear		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
361	50 Comp	RT	0.96	12800	Unknown	126.6	Unknown	42.1	18.1	4800 Bear		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
362	50 Comp	RT	0.90	13200	Unknown	123.4	Unknown	41.5	17.7	4480 Br, Comp, outside hole		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
363	50 Comp	RT	0.90	13940	Unknown	131.8	Unknown	44.2	19.0	4260 Bear		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
364	50 Comp	250	0.94	11720	Unknown	106.9	Unknown	36.0	15.5	3875 Bear		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
365	50 Comp	250	1.01	11550	Unknown	101.7	Unknown	34.5	14.7	4020 Br, Comp, outside hole		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
366	50 Comp	250	0.97	10400	Unknown	92.1	Unknown	30.9	13.4	3800 Br, Comp, outside hole		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
367	50 Comp	250	1.00	10280	Unknown	92.3	Unknown	31.2	13.4	3750 Comp, outside hole		Garbo et al. [1-38]	*Moderate delam. test; with bush.	
368	50 Comp	250	0.92	10200	Unknown	94.4	Unknown	31.5	13.5	3175 Br, Comp, outside hole		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
369	50 Comp	250	0.89	11080	Unknown	104.4	Unknown	34.6	14.9	3505 Br, Comp, outside hole		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
370	50 Comp	250	0.83	9600	Unknown	93.8	Unknown	31.2	13.4	3180 Bear		Garbo et al. [1-38]	*Severe delaminal. test, with bush.	
371	50 Comp	250	0.94	10790	Unknown	98.3	Unknown	32.8	14.1	3445 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
372	50 Comp	RT	0.89	12380	Unknown	115.8	Unknown	39.0	18.8	3940 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
373	50 Comp	RT	1.02	13500	Unknown	124.7	Unknown	41.4	17.9	4280 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
374	50 Comp	RT	1.11	13420	Unknown	117.2	Unknown	39.0	16.8	4365 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
375	50 Comp	RT	0.99	13140	Unknown	119.1	Unknown	39.8	17.2	4070 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
376	50 Comp	RT	0.99	13060	Unknown	122.0	Unknown	41.0	17.8	4190 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
377	50 Comp	RT	0.98	14080	Unknown	128.7	Unknown	43.7	18.7	4605 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
378	50 Comp	RT	0.96	14220	Unknown	130.6	Unknown	45.1	19.4	4825 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
379	50 Comp	RT	0.99	14100	Unknown	130.6	Unknown	44.0	18.9	4140 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
380	50 Comp	250	1.00	6420	Unknown	55.7	Unknown	18.8	8.1	1975 Comp, outside hole		Garbo et al. [1-38]	*Severe porosity, with bushing	
381	50 Comp	250	0.96	7260	Unknown	67.2	Unknown	22.4	9.7	2430 Comp, outside hole		Garbo et al. [1-38]	*Severe porosity, with bushing	
382	50 Comp	250	0.98	8980	Unknown	81.7	Unknown	27.2	11.7	2976 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
383	50 Comp	250	1.01	9140	Unknown	83.7	Unknown	27.9	12.0	2835 Bear		Garbo et al. [1-38]	*Severe porosity, with bushing	
384	50 Comp	250	0.96	9780	Unknown	88.9	Unknown	26.8	12.8	3080 Br, Comp, outside hole		Garbo et al. [1-38]	*Moderate porosity, with bushing	
385	50 Comp	250	1.00	10200	Unknown	92.1	Unknown	31.1	13.3	3180 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
386	50 Comp	250	1.01	10130	Unknown	92.4	Unknown	31.0	13.3	3165 Br, Comp, outside hole		Garbo et al. [1-38]	*Moderate porosity, with bushing	
387	50 Comp	250	1.00	9660	Unknown	87.2	Unknown	29.3	12.6	3050 Bear		Garbo et al. [1-38]	*Moderate porosity, with bushing	
388	50 Comp	250	0.88	10080	Unknown	93.7	Unknown	31.4	13.1	2970 Bear		Garbo et al. [1-38]	*Tilted Oak away bear surface, Bu.	
389	50 Comp	250	0.88	9560	Unknown	90.9	Unknown	30.4	13.1	3030 Br, Comp, outside hole		Garbo et al. [1-38]	*Tilted Oak away bear surface, Bu.	
390	50 Comp	250	0.88	9500	Unknown	91.0	Unknown	30.3	13.0	2690 Bear		Garbo et al. [1-38]	*Tilted Oak away bear surface, Bu.	
391	50 Comp	250	0.93	9940	Unknown	91.1	Unknown	30.4	13.1	3285 Bear		Garbo et al. [1-38]	*Tilted Oak away bear surface, Bu.	

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P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
392	50 Comp	250	0.92	10230	Unknown	91.2	Unknown	31.6	13.5	3145	Bear	Garbo et al 1-38	*Tilted Csk tow. bear surface, Bu.	
393	50 Comp	250	0.90	10020	Unknown	93.4	Unknown	31.2	13.4	3095	Bear	Garbo et al 1-38	*Tilted Csk tow. bear surface, Bu.	
394	50 Comp	250	0.90	9560	Unknown	91.4	Unknown	30.5	13.1	2770	Br, Comp, outside br	Garbo et al 1-38	*Tilted Csk tow. bear surface, Bu.	
395	50 Comp	250	0.86	9280	Unknown	92.0	Unknown	30.6	13.2	2580	Bear	Garbo et al 1-38	*Tilted Csk tow. bear surface, Bu.	
396	50 Comp	250	0.92	11060	Unknown	98.9	Unknown	33.6	14.4	3910	Br, Comp, outside br	Garbo et al 1-38	*Bolt inst. & remv. 100 times, Bush	
397	50 Comp	250	1.01	10350	Unknown	92.6	Unknown	31.2	13.3	3585	Br, Comp, outside br	Garbo et al 1-38	*Bolt inst. & remv. 100 times, Bush	
398	50 Comp	250	0.87	10030	Unknown	93.1	Unknown	31.6	13.6	3315	Br, Comp, outside br	Garbo et al 1-38	*Bolt inst. & remv. 100 times, Bush	
399	50 Comp	250	1.01	9910	Unknown	85.0	Unknown	30.0	12.8	3230	Br, Comp, outside br	Garbo et al 1-38	*Bolt inst. & remv. 100 times, Bush	
400	100 Tens	RT	0.00	9490		134.4		44.8	19.2		Br, Spl.	Ramkumar... 1-37		
401	100 Tens	RT	0.00	9555	114.7	136.3	38.21	45.1	19.3		Sh, Spl, Del	Ramkumar... 1-37	8.1	
402	100 Tens	RT	0.00	9485		134.0		44.6	19.1	4182	Br, Spl.	Ramkumar... 1-37		
403	100 Tens	RT	0.00	9599		134.7		44.9	19.2		Br, Spl.	Ramkumar... 1-37		
404	100 Tens	RT	0.00	9135	109.5	126.2	36.47	42.7	18.3	4064	Br, Spl.	Ramkumar... 1-37	7.8	
405	100 Tens	RT	0.00	9492		135.6		45.2	18.4		Br, Spl.	Ramkumar... 1-37		
406	100 Tens	RT	0.00	9526	87.8	134.9	29.25	44.9	19.3	4197	Br, Spl.	Ramkumar... 1-37	6.2	
407	100 Tens	RT	0.00	9831		139.2		46.4	19.9		Br, Del	Ramkumar... 1-37		
408	100 Tens	RT	0.00	9195	108.1	121.4	36.03	40.4	17.3	2946	Sh, Spl, Del	Ramkumar... 1-37	7.3	
409	100 Tens	RT	0.00	7706		114.2		38.0	16.3		Sh, Spl, Del	Ramkumar... 1-37		
410	100 Tens	RT	0.00	7855		117.5		39.1	16.8		Sh, Spl, Del	Ramkumar... 1-37		
411	100 Tens	RT	0.00	9367	117.7	141.4	39.22	47.1	20.2	5675	Br, Spl.	Ramkumar... 1-37	7.8	
412	100 Tens	RT	0.00	9697		148.4		48.8	20.9		Tens, Del	Ramkumar... 1-37		
413	100 Tens	RT	0.00	7697		116.2		38.7	16.6		Br, Spl.	Ramkumar... 1-37		
414	100 Tens	RT	0.00	9399		141.9		47.3	20.3		Sh, Del	Ramkumar... 1-37		
415	100 Tens	RT	0.00	8911	112.3	125.1	37.41	41.7	17.9	3611	Br, Spl.	Ramkumar... 1-37	8	
416	100 Tens	RT	0.00	8813		123.7		41.2	17.7	3648	Sh, Del	Ramkumar... 1-37		
417	100 Comp	RT	0.00	8324	-88.4	-116.8	-29.46	-38.9	-16.7	3693	Br, Spl.	Ramkumar... 1-37	-6.3	
418	100 Comp	RT	0.00	-9233		-128.5		-42.8	-18.4		Br, Spl.	Ramkumar... 1-37		
419	100 Comp	RT	0.00	9301		-130.5		-43.5	-18.6		Br, Spl.	Ramkumar... 1-37		
420	100 Tens	RT	0.00	8896	77.2	124.9	25.72	41.6	17.8	3901	Clew, Del	Ramkumar... 1-37	5.5	
421	100 Tens	RT	0.00	10454		148.7		48.9	21.0		Tens	Ramkumar... 1-37		
422	100 Tens	RT	0.00	9438		132.5		44.1	18.9		Clew, Del	Ramkumar... 1-37	7.5	
423	100 Tens	218	0.70	9819	103.4	135.4	34.46	45.1	19.3	4583	Bear	Ramkumar... 1-37		
424	100 Tens	218	0.70	9809		138.9		46.3	19.8		Bear	Ramkumar... 1-37		
425	100 Tens	218	0.70	9760		133.5		44.5	19.1		Bear	Ramkumar... 1-37	4.5	
426	100 Tens	218	0.70	6414	63.7	90.8	21.23	30.3	13.0	Gage failed				
427	100 Tens	218	0.70	7445		105.4		35.1	15.1		Br, Spl.	Ramkumar... 1-37		
428	100 Tens	218	0.70	7455		102.8		34.3	14.7	3502	Br, Spl.	Ramkumar... 1-37		
429	100 Comp	218	0.70	-7318		-102.7		-34.2	-14.7		Comp offset hol	Ramkumar... 1-37		
430	100 Comp	218	0.70	-7532		-104.8		-34.9	-15.0		Comp offset hol	Ramkumar... 1-37		
431	100 Comp	218	0.70	-8285	-87.7	-115.4	-29.20	-38.4	-16.5		Comp offset hol	Ramkumar... 1-37	-6.3	
432	0 Tens	RT	0.00	9388		122.0		40.6	17.4		Br, Spl.	Ramkumar... 1-37		
433	0 Tens	RT	0.00	7892		111.2		37.3	15.9		Br, Spl.	Ramkumar... 1-37		
434	0 Tens	RT	0.00	9170	94.8	127.6	31.52	42.5	18.2	4194	Sh, Spl, Del	Ramkumar... 1-37	6.8	
435	0 Tens	RT	0.00	8798		124.8		41.5	17.8		Br, Spl.	Ramkumar... 1-37		
436	200 Tens	RT	0.00	10198		144.4		48.1	20.6		Tens	Ramkumar... 1-37		
437	200 Tens	RT	0.00	10801		147.5		49.1	21.1		Br, Spl, Del	Ramkumar... 1-37		
438	200 Tens	RT	0.00	9839	111.3	136.9	37.08	45.6	19.6	4198	Br, Spl, Del	Ramkumar... 1-37	8	
439	200 Tens	RT	0.00	10479		148.4		49.4	21.2		Br, Spl, Del	Ramkumar... 1-37		
440	100 Tens	RT	0.00	8439	106.2	119.5	35.38	39.8	19.9	3832	Clew, Del	Ramkumar... 1-37	7.5	
441	100 Tens	RT	0.00	9330		132.1		44.0	22.0		Sh, Spl, Del	Ramkumar... 1-37		
442	100 Tens	RT	0.00	9306		131.8		43.9	22.0		Clew, Del	Ramkumar... 1-37		
443	100 Tens	RT	0.00	8219	107.1	114.4	35.69	38.1	22.9	3408	Clew, Del	Ramkumar... 1-37	7.7	
444	100 Tens	RT	0.00	8903		127.2		42.4	25.4		Clew, Del	Ramkumar... 1-37		
445	100 Tens	RT	0.00	9189		132.5		44.1	26.5		Clew, Del	Ramkumar... 1-37		
446	100 Tens	RT	0.00	8448	96.7	98.4	31.88	32.1	19.3	2371	Sh, Spl, Del	Ramkumar... 1-37	6.4	
447	100 Tens	RT	0.00	6778		101.4		33.6	20.3		Sh, Spl, Del	Ramkumar... 1-37		

### Multiple Joints

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
448AS1/3501-6	70/20/10	[45/0/-45/0/45/90/0/3]e	1.876	0.104	0.3125	0.9375/2 x 1	N/A	0.625	6.003	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]e	1.876	0.106	0.125	0.9375/2 x 1	N/A	0.625	6.003	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]e	1.876	0.107	0.125	0.9375/2 x 1	N/A	0.625	6.003	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	30/60/10	[45/0/-45/0/45/90/-45/0/45/-45]e	1.876	0.106	0.3125	0.9375/2 x 1	N/A	0.625	6.003	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.118	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.118	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Single	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.116	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.117	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/20/90]e	3.125	0.115	0.3125	0.9375/2 x 2	1.250	1.250	5.000	3.0	Double	0.3125	St Pr.	head 51B464-5
448AS1/3501-6	50/40/10	[45/0/-45/0/2												

## Multiple Joints

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
446	100 Tens	RT	RT	0.00	6815		104.6		34.9	21.0		Sh, Spl, Del	Ramkumar... 1-37		
449	100 Tens	RT	RT	0.00	8534	111.7	128.8	37.21	42.9	25.8	52.40	Sh, Del	Ramkumar... 1-37		7.4
450	100 Tens	RT	RT	0.00	9898		134.4		44.8	26.9		Sh, Del	Ramkumar... 1-37		
451	100 Tens	RT	RT	0.00	9160		139.6		46.5	27.9		Sh, Del	Ramkumar... 1-37		
452	100 Tens	RT	RT	0.00	18149	93.8	122.0	37.42	49.2	17.6	51.54	Tens, Del	Ramkumar... 1-37		13.8
453	100 Tens	RT	RT	0.00	18271		124.9		50.0	17.8		Clev, Del	Ramkumar... 1-37		
454	100 Tens	RT	RT	0.00	14979		103.3		41.3	14.8		Clev, Del	Ramkumar... 1-37		
455	100 Tens	RT	RT	0.00	15950	99.3	110.0	39.72	44.0	15.7	44.24	Tens	Ramkumar... 1-37		14.4
456	100 Tens	RT	RT	0.00	14863		102.5		41.0	14.6		Tens	Ramkumar... 1-37		
457	100 Tens	RT	RT	0.00	15805		116.9		46.8	16.7		Tens	Ramkumar... 1-37		
458	100 Tens	RT	218	0.70	18271	101.9	124.9	40.75	50.0	17.8	53.42	Sh, Del, Clev	Ramkumar... 1-37		14.9
459	100 Tens	RT	218	0.70	17831		123.0		49.2	17.6		Sh, Del, Clev	Ramkumar... 1-37		
460	100 Tens	RT	218	0.70	18173		124.3		49.7	17.8		Sh, Del, Clev	Ramkumar... 1-37		
461	100 Tens	RT	RT	0.00	15845	87.7	108.8	35.08	43.5	16.5	43.77	Clev, Del	Ramkumar... 1-37		12.8
462	100 Tens	RT	RT	0.00	15046		104.7		41.9	15.0		Clev, Del	Ramkumar... 1-37		
463	100 Tens	RT	RT	0.00	14631		100.0		40.0	14.3		Clev, Del	Ramkumar... 1-37		
464	100 Tens	RT	RT	0.00	14436		111.0		44.4	15.9	33.27	Sh, Del	Ramkumar... 1-37		
465	100 Tens	RT	RT	0.00	16288		123.9		49.6	17.7		Sh, Del	Ramkumar... 1-37		
466	100 Tens	RT	RT	0.00	14118		107.6		43.0	15.4		Sh, Del	Ramkumar... 1-37		
467	100 Tens	RT	RT	0.00	17123		129.2		51.7	16.5	68.28	Tens, Del	Ramkumar... 1-37		
468	100 Tens	RT	RT	0.00	16231		122.5		49.0	17.5		Tens, Del	Ramkumar... 1-37		14.5
469	100 Tens	RT	RT	0.00	15975	108.4	119.4	43.38	47.6	17.1		Tens, Del	Ramkumar... 1-37		14
470	100 Tens	RT	RT	0.00	15095	99.1	106.9	44.04	47.9	17.8	48.94	Tens-clev, Del	Ramkumar... 1-37		
471	100 Tens	RT	RT	0.00	13481		94.6		42.0	15.8		Tens-clev, Del	Ramkumar... 1-37		
472	100 Tens	RT	RT	0.00	15254		107.0		47.6	17.8		Tens, Del	Ramkumar... 1-37		
473	100 Comp	RT	RT	0.00	17025	-88.1	-115.4	-35.25	-46.2	-19.2		Comp offset ho	Ramkumar... 1-37		-13
474	100 Comp	RT	RT	0.00	15926		-109.8		-43.9	-18.3		Net Sect. Comp	Ramkumar... 1-37		
475	100 Comp	RT	RT	0.00	17680		-120.8		-48.3	-20.1		Comp offset ho	Ramkumar... 1-37		
476	100 Tens	RT	RT	0.00	18222		132.5		55.2	18.4	44.70	Tens	Ramkumar... 1-37		
477	100 Tens	RT	RT	0.00	17318		111.3		46.4	15.5		Tens	Ramkumar... 1-37		
478	100 Tens	RT	RT	0.00	17611		110.9		46.2	15.4		Tens	Ramkumar... 1-37		
479	100 Tens	RT	RT	0.00	16489	112.7	114.7	46.96	47.8	15.9	41.77	Tens	Ramkumar... 1-37		16.2
480	100 Tens	RT	RT	0.00	17440		116.8		48.6	16.2		Tens	Ramkumar... 1-37		
481	100 Tens	RT	RT	0.00	15804		109.0		45.4	15.1		Tens	Ramkumar... 1-37		
482	100 Tens	RT	RT	0.00	15779		109.3		45.5	15.2		Tens	Ramkumar... 1-37		
483	100 Tens	RT	RT	0.00	15730		109.4		45.6	15.2		Tens	Ramkumar... 1-37		
484	100 Tens	RT	RT	0.00	15486		106.8		44.5	14.8		Tens	Ramkumar... 1-37		
485	250 Tens	RT	RT	0.00	15315		106.1		44.2	14.7		Tens	Ramkumar... 1-37		
486	250 Tens	RT	RT	0.00	14802		103.0		42.9	14.3		Tens	Ramkumar... 1-37		
487	250 Tens	RT	RT	0.00	14729		100.3		41.8	13.9		Tens	Ramkumar... 1-37		
488	61 Tens	RT	RT	Unknown	2366	Unknown	57.4	Unknown	14.2	14.2	Unknown	Tens, Sh, Br	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
489	61 Tens	RT	RT	Unknown	4788	Unknown	85.1	Unknown	21.5	14.3	Unknown	Sh, Tens, Br	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
490	61 Tens	RT	RT	Unknown	2230	Unknown	85.7	Unknown	38.0	10.9	Unknown	Tens-clev	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
491	61 Tens	RT	RT	Unknown	3517	Unknown	75.9	Unknown	26.8	10.7	Unknown	Tens	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
492	61 Tens	RT	RT	Unknown	5841	Unknown	80.5	Unknown	33.5	13.9	Unknown	Tens	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
493	61 Tens	RT	RT	Unknown	6172	Unknown	66.1	Unknown	32.6	8.9	Unknown	Tens	Pyne, Mathew 1-3 Gl is Silenka, Resin supplier: Shell		
494	0.0 Tens	RT	RT	Unknown	8168	Unknown	99.1	Unknown	33.9	18.52	Unknown	Tens	Chang, Scott 1-40 Data is an average of 3 spec.		
495	0.0 Tens	RT	RT	Unknown	5888	Unknown	89.4	Unknown	23.0	14.90	Unknown	Tens, Bear	Chang, Scott 1-40 Data is an average of 3 spec.		
496	0.0 Tens	RT	RT	Unknown	5937	Unknown	95.0	Unknown	24.8	15.93	Unknown	Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
497	0.0 Tens	RT	RT	Unknown	4378	Unknown	70.0	Unknown	76.8	11.87	Unknown	Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
498	0.0 Tens	RT	RT	Unknown	4837	Unknown	74.2	Unknown	39.5	12.37	Unknown	Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
499	0.0 Tens	RT	RT	Unknown	5856	Unknown	90.5	Unknown	23.4	15.08	Unknown	Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
500	0.0 Tens	RT	RT	Unknown	5230	Unknown	83.7	Unknown	27.9	13.85	Unknown	Sh, Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
501	0.0 Tens	RT	RT	Unknown	6178	Unknown	82.8	Unknown	20.4	13.80	Unknown	Sh, Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
502	0.0 Tens	RT	RT	Unknown	4950	Unknown	79.2	Unknown	20.4	13.20	Unknown	Sh, Tens	Chang, Scott 1-40 Data is an average of 4 spec.		
503	0.0 Tens	RT	RT	Unknown	2888	Unknown	47.3	Unknown	16.2	7.89	Unknown	Tens	Chang, Scott 1-40 Data is an average of 3 spec.		

## Multiple Joints

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
504	T300/1034-C	0/100/0	((±45)°)	1.943	0.125	0.250	0.75	1 x 2	1.25	N/A	3.886	3.000	Sym.	0.25	Pin
505	T300/1034-C	0/100/0	((±45)°)	1.929	0.125	0.250	0.75	1 x 2	0.75	N/A	3.868	3.000	Sym.	0.25	Pin
506	T300/1034-C	25/50/25	((0/±45/90)°)	0.513	0.125	0.250	0.375	2 x 1	N/A	0.375	2.052	1.500	Sym.	0.25	Pin
507	T300/1034-C	25/50/25	((0/±45/90)°)	0.928	0.125	0.250	0.375	2 x 1	N/A	0.925	2.512	1.500	Sym.	0.25	Pin
508	T300/1034-C	25/50/25	((0/±45/90)°)	0.711	0.125	0.250	0.375	2 x 1	N/A	0.75	2.844	3.000	Sym.	0.25	Pin
509	T300/1034-C	25/50/25	((0/±45/90)°)	0.714	0.125	0.250	0.375	2 x 1	N/A	1.25	2.856	3.000	Sym.	0.25	Pin
510	T300/1034-C	25/50/25	((0/±45/90)°)	1.206	0.125	0.250	0.375	2 x 1	N/A	0.75	4.924	3.000	Sym.	0.25	Pin
511	T300/1034-C	25/50/25	((0/±45/90)°)	1.211	0.125	0.250	0.375	2 x 1	N/A	1.25	4.944	3.000	Sym.	0.25	Pin
512	T300/1034-C	N/A	((90)2/±60/±30)2°	0.507	0.125	0.250	0.375	2 x 1	N/A	0.375	2.028	1.500	Sym.	0.25	Pin
513	T300/1034-C	N/A	((90)2/±60/±30)2°	0.929	0.125	0.250	0.375	2 x 1	N/A	0.925	2.516	1.500	Sym.	0.25	Pin
514	T300/1034-C	N/A	((90)2/±60/±30)2°	0.972	0.125	0.250	0.375	2 x 1	N/A	0.75	2.988	3.000	Sym.	0.25	Pin
515	T300/1034-C	N/A	((90)2/±60/±30)2°	0.727	0.125	0.250	0.375	2 x 1	N/A	1.25	2.908	3.000	Sym.	0.25	Pin
516	T300/1034-C	N/A	((90)2/±60/±30)2°	1.208	0.125	0.250	0.375	2 x 1	N/A	0.75	4.932	3.000	Sym.	0.25	Pin
517	T300/1034-C	N/A	((90)2/±60/±30)2°	1.161	0.125	0.250	0.375	2 x 1	N/A	1.25	4.944	3.000	Sym.	0.25	Pin
518	T300/1034-C	50/0/50	((0/90)°)	0.937	0.125	0.250	0.375	2 x 1	N/A	0.375	2.548	1.500	Sym.	0.25	Pin
519	T300/1034-C	50/0/50	((0/90)°)	0.939	0.125	0.250	0.375	2 x 1	N/A	0.925	2.556	1.500	Sym.	0.25	Pin
520	T300/1034-C	50/0/50	((0/90)°)	0.751	0.125	0.250	0.375	2 x 1	N/A	0.75	3.004	3.000	Sym.	0.25	Pin
521	T300/1034-C	50/0/50	((0/90)°)	0.75	0.125	0.250	0.375	2 x 1	N/A	1.25	3.000	3.000	Sym.	0.25	Pin
522	T300/1034-C	50/0/50	((0/90)°)	1.258	0.125	0.250	0.375	2 x 1	N/A	0.75	5.032	3.000	Sym.	0.25	Pin
523	T300/1034-C	50/0/50	((0/90)°)	1.257	0.125	0.250	0.375	2 x 1	N/A	1.25	5.028	3.000	Sym.	0.25	Pin
524	T300/1034-C	0/100/0	((±45)°)	0.514	0.125	0.250	0.375	2 x 1	N/A	0.375	2.056	1.500	Sym.	0.25	Pin
525	T300/1034-C	0/100/0	((±45)°)	0.917	0.125	0.250	0.375	2 x 1	N/A	0.925	2.468	1.500	Sym.	0.25	Pin
526	T300/1034-C	0/100/0	((±45)°)	0.882	0.125	0.250	0.375	2 x 1	N/A	0.75	2.728	3.000	Sym.	0.25	Pin
527	T300/1034-C	0/100/0	((±45)°)	0.707	0.125	0.250	0.375	2 x 1	N/A	1.25	2.828	3.000	Sym.	0.25	Pin
528	T300/1034-C	0/100/0	((±45)°)	1.196	0.125	0.250	0.375	2 x 1	N/A	0.75	4.784	3.000	Sym.	0.25	Pin
529	T300/1034-C	0/100/0	((±45)°)	1.204	0.125	0.250	0.375	2 x 1	N/A	1.25	4.816	3.000	Sym.	0.25	Pin

## Multiple Joints

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
504	0.0 Tens	RT	RT	Unknown	3325 Unknown	53.2 Unknown	13.7	Unknown	8.87	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
505	0.0 Tens	RT	RT	Unknown	3377 Unknown	54.0 Unknown	14.0	Unknown	9.01	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
506	0.0 Tens	RT	RT	Unknown	2730 Unknown	43.7 Unknown	42.6	Unknown	14.6	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
507	0.0 Tens	RT	RT	Unknown	2860 Unknown	45.8 Unknown	36.4	Unknown	11.4	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 2 spec.	
508	0.0 Tens	RT	RT	Unknown	3052 Unknown	48.6 Unknown	34.3	Unknown	8.1	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
509	0.0 Tens	RT	RT	Unknown	3125 Unknown	50.0 Unknown	35.0	Unknown	6.3	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
510	0.0 Tens	RT	RT	Unknown	5405 Unknown	86.5 Unknown	35.9	Unknown	14.4	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
511	0.0 Tens	RT	RT	Unknown	5812 Unknown	93.0 Unknown	38.4	Unknown	11.6	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
512	0.0 Tens	RT	RT	Unknown	2005 Unknown	32.1 Unknown	31.6	Unknown	10.7	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
513	0.0 Tens	RT	RT	Unknown	2355 Unknown	37.7 Unknown	30.0	Unknown	9.4	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
514	0.0 Tens	RT	RT	Unknown	2135 Unknown	34.2 Unknown	25.4	Unknown	5.7	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 3 spec.	
515	0.0 Tens	RT	RT	Unknown	2412 Unknown	38.6 Unknown	26.5	Unknown	4.8	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
516	0.0 Tens	RT	RT	Unknown	3868 Unknown	61.9 Unknown	25.6	Unknown	10.3	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 3 spec.	
517	0.0 Tens	RT	RT	Unknown	3887 Unknown	62.2 Unknown	26.8	Unknown	7.8	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
518	0.0 Tens	RT	RT	Unknown	2560 Unknown	41.0 Unknown	32.2	Unknown	13.7	Unknown	Sh, Sh, Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
519	0.0 Tens	RT	RT	Unknown	3191 Unknown	51.1 Unknown	39.9	Unknown	12.8	Unknown	Sh, Sh, Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
520	0.0 Tens	RT	RT	Unknown	3725 Unknown	59.6 Unknown	39.7	Unknown	9.9	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
521	0.0 Tens	RT	RT	Unknown	4145 Unknown	66.3 Unknown	44.2	Unknown	8.3	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
522	0.0 Tens	RT	RT	Unknown	4862 Unknown	77.8 Unknown	30.9	Unknown	13.0	Unknown	Sh, Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
523	0.0 Tens	RT	RT	Unknown	5616 Unknown	89.9 Unknown	35.7	Unknown	11.2	Unknown	Br, Sh	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 3 spec.	
524	0.0 Tens	RT	RT	Unknown	1380 Unknown	22.1 Unknown	21.5	Unknown	7.4	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
525	0.0 Tens	RT	RT	Unknown	1522 Unknown	24.4 Unknown	19.7	Unknown	6.1	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
526	0.0 Tens	RT	RT	Unknown	1480 Unknown	23.7 Unknown	17.4	Unknown	3.9	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
527	0.0 Tens	RT	RT	Unknown	1500 Unknown	24.0 Unknown	17.0	Unknown	3.0	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
528	0.0 Tens	RT	RT	Unknown	3362 Unknown	53.8 Unknown	22.5	Unknown	9.0	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	
529	0.0 Tens	RT	RT	Unknown	3412 Unknown	54.6 Unknown	22.7	Unknown	6.8	Unknown	Tens	Chang, Scott... [1-40]	Chang, Scott... [1-40]	Data is an average of 4 spec.	

**Appendix B-1. Adhesive properties.**

1	A	B	C	D	E	F	G	H	I	J		K	L		M	N
										Final	Secant		Ultimate	Tensile		
2	Adhesive	Adhesive	Testing	Load Rate	Initial Young's	Poisson's	Initial Shear	Elastic	Elastic	Final	Secant	Final	Ultimate	Tensile	Ultimate	Ultimate
3		Thickness	Temp.	in./min.	Modulus	Ratio	Modulus	Limit of	Limit of	Secant	Secant	Secant	Strength	Strength	Strength	Compress.
4		ID	ure. °E	or Δ(%)S	E, ksi	γ	G, ksi	E(p), ksi	G(p), ksi	E(US), ksi	G(US), ksi	G(US), ksi	Strength	Strength	Strain, %	Strength, ksi
4	Redux K-6		RM		500.00	0.360	184.00	5.45	5			4.93	8.3			
5	AF-6		RM		18.20	0.494	6.10		3.71			6.25				
6	AF-6		RM		9.50	0.490	3.20	1.68					2.4			
7	MN3C		RM		5.20	0.498	1.53	0.73	2.43			1.36	1.22			
8	Epon VIII		RM		508.00	0.412	180.00		4.75			60.42				
9	Metibond 4021		RM		16.20	0.472	5.52	1.3	1.14				2.71			
10	Metibond 4021		RM		6.36	0.497	2.12					2.00				
11	FM 47		RM		325.00	0.385	117.00	3.42	2.33			63.64	4.35			
12	Epon 422J		RM		395.00	0.294	160.00		3.23			99.06	2.56			
13	Metibond 408		RM		139.00	0.410	49.30		1.87			2.39	8			
14	FM 1000		RM		180.00	0.408	64.10		3.4			2.13	6.99			
15	EA 9320	T=118, C=394	RM	1.969	340.4	0.354		1.74		170.8			6.83	4		8.95
16	3M EC 2216 A/B	T=118, C=394	RM	1.969	242.2	0.38		1.59		17.6			4.41	25		16.52
17	CB75&R221-75	T=118, C=394	RM	1.969	37.7	0.075		0.33		3.3			1.12	34		7.95
18	Metibond 1113	0.140	RM	Δ6.81E-4	311.9	0.351		2.9		168.0			6.72	4		
19	Metibond 1113	0.140	RM	Δ6.83E-3	329.9	0.382		2.9		176.8			7.25	4.1		
20	Metibond 1113	0.140	RM	Δ3.35E-2	319.9	0.390		2.9					7.49			
21	Metibond 1113	0.140	RM	Δ6.55E-2	332.9	0.360		2.9		193.2			7.92	4.1		
22	Metibond 1113	0.140	RM	Δ6.68E-1	329.9	0.370		2.9		253.9			8.38	3.3		
23	Metibond 1113-2	0.140	RM	Δ7.00E-4	290.9	0.380		2.03		108.8			5.66	5.2		
24	Metibond 1113-2	0.140	RM	Δ6.75E-3	299.9	0.392		2.03		121.4			6.19	5.1		
25	Metibond 1113-2	0.140	RM	Δ3.40E-2	280.1	0.357		2.03					6.19			
26	Metibond 1113-2	0.140	RM	Δ7.05E-2	294.9	0.343		2.03		123.5			6.67	5.4		
27	Metibond 1113-2	0.140	RM	Δ6.35E-1	299.9	0.366		2.03		149.4			7.77	5.2		
28	Metibond 1113		RM		325	0.366		1.58					7.90			
29	Metibond 1113		RM				36.3		1.32							
30	AF 126-2		RM		455	0.300		1.58					12.00			
31	AF 126-2		RM				17.5		0.1							
32	Polyurethane	0.065	RM	0.050									3.31			
33	Polyurethane	0.006	RM	0.050									4.85			
34	Polyurethane	0.065	RM	0.050									5.82			
35	Polyurethane	0.006	RM	0.050									5.19			
36	EA 934	0.005	RM	0.050									4.09			
37	EA 934	0.023	RM	0.050									3.24			
38	EA 934	0.068	RM	0.050									2.69			
39	EA 934	0.13	RM	0.075									2.05			
40	EA 934	0.525	RM	0.100									1.29			

Bulk-Adj

	O	P	Q	R	S	T	U	V	W
1	Ultimate	Ultimate	Ramberg-Osgood Para	Ramberg-Osgood Para	Ramberg-Osgood Para	Ramberg-Osgood Para	Testing Methods	Reference	Remarks
2	Compress.	Shear	Tension_k	Tension_k	Shear_k	Shear_k	Description		
3	Strain %	8.2					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Mati-61S AL alloy
4		3.91					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Data scatter. 200%-300%
5		2.48					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Mati-61S AL alloy
6		6.05					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Data scatter. 200%-300%
7		4.56					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Mati-61S AL alloy
8		3.72					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Data scatter. 200%-300%
9		5.52					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Mati-61S AL alloy
10		5.55					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Data scatter. 200%-300%
11		7.93					Butt joint of tubes, Dia=2, 1.5 in.	Kuenzi, Stevens [2-30]	Data scatter. 200%-300%
12	30						Ten-Dog bone flat coupon; Co Sq. block	Morozo-Villalobos [2-18]	T: 1x.118", G.L.=1.18 in.
13	39						Ten-Dog bone flat coupon; Co Sq. block	Morozo-Villalobos [2-18]	C: 0.394x.394x.984 in.
14	45						Ten-Dog bone flat coupon; Co Sq. block	Morozo-Villalobos [2-18]	
15							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
16							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
17							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
18							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
19							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
20							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
21							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
22							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
23							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
24							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
25							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
26							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
27							Dog bone flat coupon	Brinson ... [2-19]	I=0.140" W=0.5" G.L.-5.8W
28		2.039 E-33	7.907					Sancahtar [2-36]	
29		4.39				10.45		Hamhveys, Herak [2-37]	
30		2.039 E-33	7.907					Grimesa... [2-69]	
31		13.0				2.684		Anderson... [2-23]	Ad = Po. Solithane 113
32							Standard button tensile adhesion	Anderson... [2-23]	Ad = Po. Solithane 113
33							Standard button tensile adhesion	Anderson... [2-23]	Ad = Po. Solithane 113
34							Modified button tensile adhesion	Anderson... [2-23]	Ad = Po. Solithane 113
35							Modified button tensile adhesion	Anderson... [2-23]	Ad = Po. Solithane 113
36							Modified button tensile adhesion	Anderson, Devries [2-24]	Averaged of 10 specimens
37							Modified button tensile adhesion	Anderson, Devries [2-24]	Averaged of 10 specimens
38							Modified button tensile adhesion	Anderson, Devries [2-24]	Averaged of 10 specimens
39							Modified button tensile adhesion	Anderson, Devries [2-24]	Averaged of 10 specimens
40							Modified button tensile adhesion	Anderson, Devries [2-24]	Averaged of 10 specimens

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
41	EA 9309.2NA	0.065 RM		0.05								1.42		
42	EA 9309.2NA	0.005 RM		0.05								1.62		
43	EA 9309.2NA	0.065 RM		0.50								2.43		
44	EA 913	0.005 RM		0.05								1.65		
45	EA 913	0.005 RM		0.50								3.02		
46	EA 9309.2NA	0.005/.065? RM		0.005								2.64		
47	EA 9309.2NA	0.005/.065? RM		0.05								3.19		
48	EA 9309.2NA	0.005/.065? RM		0.50								3.28		
49	EA 9321	0.008 RM					149.4		0.996			8.54		
50	AV138M/HV998	0.008 RM												
51	FM 300K	0.008 RM			363.2	0.34								
52	FM 300K	0.071 RM			337.9	0.39								
53	EC 3445	0.004 RM			262.5	0.4	94.3							
54	FM 300	0.009 RM			336.5	0.4	120.4							
55	Redux 322 Ep Film	T: .0197-.394 RM			662.8	0.38	239.3							
56	Redux 322 Ep Film	S or Tor: 0.071 RM			662.8	0.38	236.4							
57	Ecoobond 45 LV	T: .0197-.394 RM			690.4	0.324	261.1							
58	Ecoobond 45 LV	S or Tor: 0.071 RM			690.4	0.324	255.3							
59	FM-73M	0.0087 RM					122.1							
60	EA 951 Film	0.0108 RM					7.99							
61	EA 951 Film	0.0096 RM					9.11							
62	EA 951 Film	0.0093 RM					10.05							
63	EA 951 Film	0.013 RM					7.44							
64	EA 951 Film	0.0127 RM					9.2							
65	EA 951 Film	0.0034 RM					3.11							
66	EA 951 Film	0.0031 RM					3.93							
67	EA 951 Film	0.004 RM					3.85							
68	EA 951 Film	0.0034 RM					1.59							
69	EA 951 Film	0.0031 RM					1.45							
70	EA 951 Film	0.0034 RM					1.77							
71	EA 951 Film	0.0012 RM			4.31	0.436	1.50							
72	EA 951 Film	0.0012 RM			4.37	0.457	1.50							
73	EA 951 Film	0.0012 RM			4.25	0.417	1.50							
74	EA 951 Film	0.0012 RM			4.31	0.436	1.50							
75	EA 951 Film	0.0028 RM			7.38	0.475	2.50							
76	EA 951 Film	0.0037 RM			8.54	0.473	2.90							
77	EA 951 Film	0.0025 RM			7.07	0.473	2.40							
78	EA 951 Film	0.0031 RM			7.62	0.485	2.60							
79	EA 951 Film	0.003 RM			7.65	0.471	2.60							
80	EA 951 Film	0.0046 RM			19.63	0.402	7.00							

## Bulk-Adj

	O	P	Q	R	S	T	U	V	W
41							Modified button tensile adhesion	Anderson...[2-25]	With Teflon spacer
42							Modified button tensile adhesion	Anderson...[2-25]	Without Teflon spacer
43							Modified button tensile adhesion	Anderson...[2-25]	With Teflon spacer
44							Modified button tensile adhesion	Anderson...[2-25]	Without Teflon spacer
45							Modified button tensile adhesion	Anderson...[2-25]	Without Teflon spacer
46							Modified button tensile adhesion	Anderson...[2-25]	Teflon spacer?
47							Modified button tensile adhesion	Anderson...[2-25]	Teflon spacer?
48							Modified button tensile adhesion	Anderson...[2-25]	Teflon spacer?
49		4.27					Stiff adherend spec., chromic acid etch	Weissberg, Arcan [2-13]	Using COD gage 2670-114
50		7.54					Stiff adherend specimen, sand blast	Weissberg, Arcan [2-13]	Using COD gage 2670-114
51							Butt joint & Thick adherend lap sh.	Jangblad...[2-21]	St butt J., AL adherend J.
52							Rectangular adhesive bulk specimen	Jangblad...[2-21]	t=0.071", W=.776"
53								Mail...[2-11]	
54								Mail...[2-11]	
55							Ten. & torsion pendulum on bulk spec.	Jeandrau [2-20]	Ten: NFT 51034, Tor:NFT51104
56							Ten.Bulk spec., Sh: thick adherend spec.	Jeandrau [2-20]	Ten: NFT 51034, Sh:DIN54451
57							Ten. & torsion pendulum on bulk spec.	Jeandrau [2-20]	Ten: NFT 51034, Tor:NFT51104
58							Ten.Bulk spec., Sh: thick adherend spec.	Jeandrau [2-20]	Ten: NFT 51034, Sh:DIN54451
59		3.92					Thick adherend lap sh. & moire interfer	Post...[2-32]	Sh is Uniform except 2 ends
60							Thick adherend lap shear	Renton, Vinson [2-31]	adhesive failure
61							Thick adherend lap shear	Renton, Vinson [2-31]	adhesive failure
62							Thick adherend lap shear	Renton, Vinson [2-31]	primarily adhesive failure
63							Thick adherend lap shear	Renton, Vinson [2-31]	primarily adhesive failure
64							Thick adherend lap shear	Renton, Vinson [2-31]	primarily adhesive failure
65							Thick adherend lap shear	Renton, Vinson [2-31]	cohesive failure
66							Thick adherend lap shear	Renton, Vinson [2-31]	cohesive failure
67							Thick adherend lap shear	Renton, Vinson [2-31]	cohesive failure
68							Thick adherend lap shear	Renton, Vinson [2-31]	resin of GI/Ep adher. failed
69							Thick adherend lap shear	Renton, Vinson [2-31]	resin of GI/Ep adher. failed
70							Thick adherend lap shear	Renton, Vinson [2-31]	resin of GI/Ep adher. failed
71							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
72							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
73							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
74							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
75							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
76							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
77							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
78							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
79							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk
80							Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk

Bulk-Adj

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
81	EA 951 Film	0.0031	RM		12.92	0.435	4.50							
82	EA 951 Film	0.0028	RM		11.47	0.434	4.00							
83	EA 951 Film	0.0034	RM		14.28	0.428	5.00							
84	EA 951 Film	0.0035	RM		14.57	0.425	5.13							
85	EA 951 Film	0.0111	RM		17.32	0.468	5.90							
86	EA 951 Film	0.0108	RM		17.36	0.471	5.90							
87	EA 951 Film	0.0111	RM		17.36	0.471	5.90							
88	EA 951 Film	0.0111	RM		17.45	0.479	5.90							
89	EA 951 Film	0.011	RM		17.37	0.472	5.90							

Bulk-Adj

O	P	Q	R	S	T	U	V	W
81						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
82						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
83						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
84						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
85						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
86						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
87						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
88						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f
89						Thick adherend lap shear	Renton, Vinson [2-31]	Moduli should not dep. on adh. thk f

**Appendix B-2. Lap shear strength of adhesives and  
composites/metals.**

	A	B	C	D	E	F	G
1	Type of	Adhesive	Overlap	Adherend	Surface	Adherend	
2	Adhesive	Thickness	Length in	materials	Preparation	Layup	Width in.
3	AF-126-2 Film	0.0010	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.000
4	AF-126-2 Film	0.0005	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.003
5	AF-126-2 Film	0.0015	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.001
6	AF-126-2 Film	0.0010	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.001
7	AF-126-2 Film	0.0030	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0]s	0.999
8	AF-126-2 Film	0.0035	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0]s	1.000
9	AF-126-2 Film	0.0025	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0]s	0.998
10	AF-126-2 Film	0.0030	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0]s	0.998
11	AF-126-2 Film	0.0015	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[0]3, [0]8	1.015
12	AF-126-2 Film	0.0025	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[0]3, [0]8	1.015
13	AF-126-2 Film	0.0028	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[0]3, [0]8	1.015
14	AF-126-2 Film	0.0023	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[0]3, [0]8	1.015
15	AF-126-2 Film	0.0020	2 x 0.218	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.013
16	AF-126-2 Film	0.0020	2 x 0.218	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.014
17	AF-126-2 Film	0.0015	2 x 0.218	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.014
18	AF-126-2 Film	0.0018	2 x 0.218	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.014
19	AF-126-2 Film	0.0025	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0)q], [(0/45/0/-45/0)q]s	1.014
20	AF-126-2 Film	0.0035	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0)q], [(0/45/0/-45/0)q]s	1.013
21	AF-126-2 Film	0.0040	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0)q], [(0/45/0/-45/0)q]s	1.015
22	AF-126-2 Film	0.0033	2 x 0.25	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0)q], [(0/45/0/-45/0)q]s	1.014
23	AF-126-2 Film	0.0015	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.010
24	AF-126-2 Film	0.0040	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.009
25	AF-126-2 Film	0.0010	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.008
26	AF-126-2 Film	0.0022	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.009
27	AF-126-2 Film	0.0050	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.008
28	AF-126-2 Film	0.0015	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.010
29	AF-126-2 Film	0.0015	0.218	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.010
30	AF-126-2 Film	0.0027	0.239	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.006
31	AF-126-2 Film	0.0010	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.017
32	AF-126-2 Film	0.0005	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.016
33	AF-126-2 Film	0.0010	2 x 0.218	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.015
34	AF-126-2 Film	0.0008	2 x 0.239	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0] 6	1.016
35	AF-126-2 Film	0.0005	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.019
36	AF-126-2 Film	0.0000	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.018
37	AF-126-2 Film	0.0002	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.017
38	AF-126-2 Film	0.0002	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.018
39	AF-126-2 Film	0.0015	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0)q/0]s	1.002
40	AF-126-2 Film	0.0005	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0)q/0]s	1.020
41	AF-126-2 Film	0.0010	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0)q/0]s	1.021
42	AF-126-2 Film	0.0010	2 x 0.25	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0)q/0]s	1.014
43	MB-329	0.0140	2.013	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2x[(0/±45/0)q]s	1.017
44	MB-329	0.0160	2.024	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2x[(0/±45/0)q]s	3.996
45	MB-329	0.0170	2.150	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2x[(0/±45/0)q]s	1.003
46	MB-329	0.0170	2.016	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2x[(0/±45/0)q]s	1.006
47	MB-329	0.0160	2.051	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2x[(0/±45/0)q]s	1.006
48	MB-329	0.0070	0.269	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/(90)2/0]4, [(0/45/0)q]s	1.003
49	MB-329	0.0070	0.284	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/(90)2/0]4, [(0/45/0)q]s	1.004
50	MB-329	0.0070	0.247	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/(90)2/0]4, [(0/45/0)q]s	1.002
51	MB-329	0.0070	0.267	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/(90)2/0]4, [(0/45/0)q]s	1.003
52	MB-329	0.0010	2.008	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0]8	0.997
53	MB-329	0.0030	2.005	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0]8	0.996
54	MB-329	0.0010	2.005	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0]8	0.997
55	MB-329	0.0017	2.006	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0]8	0.997
56	AF-126-2 Film	0.0030	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.016
57	AF-126-2 Film	0.0050	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.015
58	AF-126-2 Film	0.0050	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.015
59	AF-126-2 Film	0.0043	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0] 9	1.015
60	AF-126-2	0.0065	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[(0/45/0/-45/0)q/0]s	1.013
61	AF-126-2	0.0040	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[(0/45/0/-45/0)q/0]s	1.015
62	AF-126-2	0.0075	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[(0/45/0/-45/0)q/0]s	1.015
63	AF-126-2	0.0080	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[(0/45/0/-45/0)q/0]s	1.014
64	AF-126-2	0.0050	2 x 0.5	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.010
65	AF-126-2	0.0050	2 x 0.5	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.011

## Adhesive Lap-J

	M	I	J	K	L	M	N	O	P
1	Adherend	Joint	Length	Failure Load	Adhesive	Gross	Failure	Reference	Remarks
2	Thick. in	Type	Bot. Lab	lb/in width	Strength, psi	Strength, psi	Mode		
3	0.046	Single	4.1250	1120	4480	24.35	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
4	0.046	Single	4.1875	1100	4382	23.91	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
5	0.046	Single	4.1250	970	3880	21.09	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
6	0.046	Single	4.1250	1063	4247	23.11	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Averaged
7	0.047	Single	4.1250	1105	4420	23.51	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
8	0.047	Single	4.1250	1170	4680	24.89	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
9	0.047	Single	4.1250	1165	4679	24.79	Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
10	0.047	Single	4.1250	1147	4593	24.40	Co, Ad-Bo	Grimes...[2-69]	Averaged
11	0.028	Double	4.2500	1785	3514	63.75	Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
12	0.027	Double	4.2500	1740	3425	64.44	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
13	0.027	Double	4.2500	1825	3592	67.59	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
14	0.027	Double	4.2500	1783	3510	66.04	Co, Ad-Bo	Grimes...[2-69]	Averaged
15	0.088	Double	4.1875	1595	3608	18.13	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
16	0.088	Double	4.1875	1430	3235	18.25	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
17	0.087	Double	4.1250	1535	3473	17.84	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
18	0.088	Double	4.1250	1520	3439	17.27	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Averaged
19	0.089	Double	4.2500	2410	4744	27.08	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	(Q450V-45)q-(Q450V-45)M50V-450)
20	0.088	Double	4.2500	2225	4397	25.28	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	0' = Half a 0° ply
21	0.087	Double	4.2500	2250	4429	25.86	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
22	0.088	Double	4.2500	2295	4523	26.08	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Averaged
23	0.031, 0.032	Single	2.2500	1000	3968	32.26	Co, Sur. Re, Ad-Ti	Grimes...[2-69]	Ep: N5505
24	0.031, 0.032	Single	2.2500	820	3254	28.45	Co, Sur. Re, Ad-Ti	Grimes...[2-69]	Ep: N5505
25	0.031, 0.032	Single	2.2500	1165	4623	37.58	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Ep: N5505
26	0.031, 0.032	Single	2.2500	995	3948	32.10	Co, Sur. Res, Ad-Ti	Grimes...[2-69]	Averaged
27	0.045, 0.045	Single	2.3750	1215	4821	27.00	Ad-Bo, Ad-Ti, Co	Grimes...[2-69]	Ep: N5505
28	0.045, 0.045	Single	2.3750	1140	4524	25.33	Ad-Bo, Co, Ad-Ti	Grimes...[2-69]	Ep: N5505
29	0.045, 0.045	Single	2.3750	1045	4147	23.22	Co, Ad-Bo, Sur. Res	Grimes...[2-69]	Ep: N5505
30	0.045, 0.045	Single	2.3750	1133	4497	25.18	Ad-Bo, Co, Ad-Ti	Grimes...[2-69]	Averaged
31	0.020, 2x.018	Double	2.3125	2685	5281	92.59	Co, Sur. Re, Ad-Ti, Ad-Bo	Grimes...[2-69]	Ep: N5505
32	0.029, 2x.016	Double	2.3125	2620	5157	90.34	Co, Sur. Re, Ad-Ti, Ad-Bo	Grimes...[2-69]	Ep: N5505
33	0.029, 2x.016	Double	2.3125	2470	5581	85.17	Co, Ad-Ti, Ad-Bo, Sur. Re	Grimes...[2-69]	Ep: N5505
34	0.029, 2x.018	Double	2.25	2592	5373	89.38	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Averaged
35	0.088, 2x.045	Double	2.25	1350	2650	15.34	Co, Ad-Bo, Sur. Re, Ad-Ti	Grimes...[2-69]	Ep: N5505
36	0.089, 2x.045	Double	2.25	2055	4037	23.35	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Ep: N5505
37	0.087, 2x.045	Double	2.25	2215	4356	25.17	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Ep: N5505
38	0.088, 2x.045	Double	2.25	1873	3681	21.28	Co, Ad-Bo, Ad-Ti, Sur. Re	Grimes...[2-69]	Averaged
39	0.087, 2x.045	Double	2.25	2260	4511	25.68	Ad-Ti, Co, Sur. Re, Ad-Bo	Grimes...[2-69]	(Q450V-45)q-(Q450V-45)M50V-450)
40	0.088, 2x.045	Double	2.25	2360	4627	26.82	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	0' = Half a 0° ply
41	0.088, 2x.045	Double	2.25	2485	4868	28.24	Sur. Re, Co, Ad-Ti, Ad-Bo, Int	Grimes...[2-69]	Ep: N5505
42	0.088, 2x.045	Double	2.25	2368	4669	26.91	Co, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Averaged
43	0.168, 0.173	1-St.L.	6.4375	1700	830	10.24	Sur. Re, Ad-Ti, Co	Grimes...[2-69]	Ep: N5505
44	0.166, 0.178	1-St.L.	6.4375	1740	863	10.48	Sur. Re, Ad-Ti, Co	Grimes...[2-69]	Ep: N5505
45	0.166, 0.177	1-St.L.	6.4375	1710	793	10.30	Sur. Re, Ad-Ti, Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
46	0.166, 0.177	1-St.L.	6.4375	1830	902	11.02	Sur. Re, Ad-Ti, Co, ...	Grimes...[2-69]	Ep: N5505
47	0.166, 0.167	1-St.L.	6.4375	1745	847	10.51	Sur. Re, Ad-Ti, Co, ...	Grimes...[2-69]	Averaged
48	0.086	3-St.L-M	4.1875	850	3150	9.88	Co, Sur. Re, Inter.	Grimes...[2-69]	Ep: N5505
49	0.086	3-St.L-M	4.1875	935	3280	10.87	Sur. Re, Co, Int, Ad-Bo	Grimes...[2-69]	Ep: N5505
50	0.086	3-St.L-M	4.1875	915	3697	10.64	Int, Sur. Re, Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
51	0.086	3-St.L-M	4.1875	900	3376	10.47	Sur. Re, Co, Int, Ad-Bo	Grimes...[2-69]	Averaged
52	0.088, 0.087	1-St.L.	7.50	2835	1416	32.59	Sur. Re, Ad-Ti, Co	Grimes...[2-69]	Ep: N5505
53	0.086, 0.083	1-St.L.	7.50	2205	1104	25.34	Ad-Ti, Sur. Re, Co, Int	Grimes...[2-69]	Ep: N5505
54	0.087, 0.085	1-St.L.	7.50	2910	1458	33.45	Sur. Re, Ad-Ti, Int, Co	Grimes...[2-69]	Ep: N5505
55	0.086, 0.085	1-St.L.	7.50	2650	1325	30.46	Sur. Re, Ad-Ti, Co, Int.	Grimes...[2-69]	Averaged
56	0.044	Single	5.25	5750	4528	130.68	Sur. Re, Int, Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
57	0.043	Single	5.25	5535	4382	128.72	Sur. Re, Co, Int	Grimes...[2-69]	Ep: N5505
58	0.043	Single	5.25	5720	4508	133.02	Sur. Re, Co, Int	Grimes...[2-69]	Ep: N5505
59	0.043	Single	5.25	5668	4488	131.81	Sur. Re, Co, Int.	Grimes...[2-69]	Averaged
60	0.043	Single	3.2813	4100	3238	95.35	Ad-Bo, Sur. Re, Int	Grimes...[2-69]	0' = Half a 0° ply
61	0.044	Single	3.25	3815	3007	86.70	Ad-Bo, Sur. Re	Grimes...[2-69]	0' = Half a 0° ply
62	0.043	Single	3.25	3900	3074	90.70	Ad-Bo, Sur. Re	Grimes...[2-69]	0' = Half a 0° ply
63	0.043	Single	3.25	3938	3108	91.58	Ad-Bo, Sur. Re	Grimes...[2-69]	Averaged
64	0.031	Double	4.1875	4020	3980	129.68	Ad-Bo, Co, Sur. Re, ...	Grimes...[2-69]	Ep: N5505
65	0.031	Double	4.1875	4085	4040	131.77	Co, Ad-Bo, Sur. Re, ...	Grimes...[2-69]	Ep: N5505

Adhesive Lap-J

	A	B	C	D	E	F	G
66	AF-126-2	0.0045	2 x 0.5	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.013
67	AF-126-2	0.0048	2 x 0.5	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.013
68	AF-126-2	0.0035	2 x 0.437	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.015
69	AF-126-2	0.0025	2 x 0.437	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.013
70	AF-126-2	0.0020	2 x 0.437	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.013
71	AF-126-2	0.0027	2 x 0.437	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.014
72	AF-126-2	0.0022	2 x 0.75	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.014
73	AF-126-2	0.0018	2 x 0.75	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.013
74	AF-126-2	0.0020	2 x 0.75	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.015
75	AF-126-2	0.0020	2 x 0.75	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.014
76	AF-126-2	0.0050	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.016
77	AF-126-2	0.0055	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
78	AF-126-2	0.0070	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.014
79	AF-126-2	0.0058	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
80	AF-126-2	0.0020	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.014
81	AF-126-2	0.0020	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.013
82	AF-126-2	0.0045	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.015
83	AF-126-2	0.0028	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.014
84	AF-126-2	0.0005	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.013
85	AF-126-2	0.0000	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
86	AF-126-2	0.0002	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
87	AF-126-2	0.0003	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.014
88	AF-126-2	0.0020	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.020
89	AF-126-2	0.0020	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.019
90	AF-126-2	0.0018	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.020
91	AF-126-2	0.0019	2 x 0.5	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.020
92	AF-126-2	0.0032	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	0.962
93	AF-126-2	0.0032	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.012
94	AF-126-2	0.0025	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.004
95	AF-126-2	0.0030	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	0.993
96	MB-329	0.0100	2.012	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0/90)2/0]4	1.001
97	MB-329	0.0130	2.009	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0/90)2/0]4	1.002
98	MB-329	0.0150	2.008	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0/90)2/0]4	1.000
99	MB-329	0.0130	2.010	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	2 x [0/90)2/0]4	1.001
100	AF-126-2	0.0005	3.686	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [0/90)2/0]4	1.003
101	AF-126-2	0.0010	3.091	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [0/90)2/0]4	1.002
102	AF-126-2	0.0015	3.689	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [0/90)2/0]4	1.001
103	AF-126-2	0.0010	3.689	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [0/90)2/0]4	1.002
104	AF-126-2	0.0055	3.864	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [(0/±45/0)q]s	1.005
105	AF-126-2	0.0070	3.896	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [(0/±45/0)q]s	1.002
106	AF-126-2	0.0050	3.881	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [(0/±45/0)q]s	1.003
107	AF-126-2	0.0055	3.875	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [(0/±45/0)q]s	1.002
108	AF-126-2	0.0058	3.879	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	3 x [(0/±45/0)q]s	1.003
109	AF-126-2	0.0030	1.734	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]9	1.016
110	AF-126-2	0.0070	1.723	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]9	1.070
111	AF-126-2	0.0030	1.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]9	1.051
112	AF-126-2	0.0043	1.736	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]9	1.046
113	AF-126-2	0.0040	2.000	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.002
114	AF-126-2	0.0045	2.000	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.006
115	AF-126-2	0.0040	2.000	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.010
116	AF-126-2	0.0042	2.000	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.006
117	AF-126-2	0.0030	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.010
118	AF-126-2	0.0035	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.010
119	AF-126-2	0.0035	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.013
120	AF-126-2	0.0033	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3.[0]6	1.011
121	AF-126-2	0.0000	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.011
122	AF-126-2	0.0012	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.013
123	AF-126-2	0.0015	2 x 0.687	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.013
124	AF-126-2	0.0009	2 x 0.729	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0]. [(0/90)8/0]	1.012
125	AF-126-2	0.0042	2 x 0.125	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.013
126	AF-126-2	0.0035	2 x 0.125	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.011
127	AF-126-2	0.0034	2 x 0.125	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.013
128	AF-126-2	0.0037	2 x 0.125	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45/0)q/0]s	1.012
129	AF-126-2	0.0035	1.887	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
130	AF-126-2	0.0045	1.887	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.001

## Adhesive Lap-J

	H	I	J	K	L	M	N	O	P
66	0.032	Double	4.1875	3905	3055	122.03	Ad-Bo, Co, Sur.Re, ...	Grimes...[2-69]	Ep: N5505
67	0.031	Double	4.1875	4003	3058	129.13	Ad-Bo, Co, Sur.Re, ...	Grimes...[2-69]	Averaged
68	0.086	Double	4.4063	4900	5524	56.98	Co, Ad-Bo	Grimes...[2-69]	Ep: N5505
69	0.087	Double	4.4063	4890	5523	56.21	Co, Ad-Bo, Int	Grimes...[2-69]	Ep: N5505
70	0.087	Double	4.3750	4555	5144	52.36	Ad-Bo, co, ...	Grimes...[2-69]	Ep: N5505
71	0.087	Double	4.4063	4782	5397	54.97	Co, Ad-Bo, ...	Grimes...[2-69]	Averaged
72	0.088	Double	4.3750	7160	4707	81.36	Co, Sur.Re, Ad-Bo	Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
73	0.088	Double	4.6250	7185	4728	81.66	Co, Sur.Re, Ad-Bo	Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
74	0.088	Double	4.6250	6710	4407	76.25	Co, Ad-Bo, Sur.Fle	Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
75	0.088	Double	4.5313	7018	4614	79.75	Co, Sur.Re, Ad-Bo	Grimes...[2-69]	Averaged
76	0.031, 0.032	Single	3.1875	4280	3370	138.06	Ad-Ti, Co,Sur.Re, Int	Grimes...[2-69]	Ep: N5505
77	0.031, 0.032	Single	3.1875	4195	3308	135.32	Sur.Re,Int, Ad-Ti, Co	Grimes...[2-69]	Ep: N5505
78	0.031, 0.032	Single	3.1875	4115	3246	132.74		Grimes...[2-69]	Ep: N5505
79	0.031, 0.032	Single	3.1875	4197	3307	135.39	Co,Ad-Ti,Sur.Re, Int	Grimes...[2-69]	Averaged
80	0.047, 0.045	Single	3.25	4400	3471	93.62		Grimes...[2-69]	0' = Half a 0° ply
81	0.047, 0.045	Single	3.25	4010	3167	85.32	Sur.Re, Int, Co	Grimes...[2-69]	0' = Half a 0° ply
82	0.047, 0.045	Single	3.25	4355	3432	92.66		Grimes...[2-69]	0' = Half a 0° ply
83	0.047, 0.045	Single	3.25	4255	3357	90.53	Sur.Re, Int, ...	Grimes...[2-69]	Averaged
84	0.030,2x.016	Double	2.50	3990	3939	133.00	Co,Sur.Re,Ad-Bo,Ad-Ti	Grimes...[2-69]	
85	0.030,2x.016	Double	2.50	4010	3958	133.67	Other	Grimes...[2-69]	
86	0.030,2x.016	Double	2.50	3840	3783	128.00	Other	Grimes...[2-69]	
87	0.030,2x.016	Double	2.50	3947	3893	131.57	Other,Co, Sur.Re	Grimes...[2-69]	Averaged
88	0.085,2x.046	Double	2.50	5250	5147	61.76	Int,Sur.Re,Co,Ad-Ti	Grimes...[2-69]	
89	0.085,2x.045	Double	2.50	5200	5103	61.18	Other	Grimes...[2-69]	
90	0.085,2x.045	Double	2.50	5210	5108	61.29	Co,Sur.Re,Ad-Ti,Int	Grimes...[2-69]	
91	0.085,2x.046	Double	2.50	5220	5119	61.41	Co,Sur.Re,Int,Ad-Ti	Grimes...[2-69]	Averaged
92	0.087,2x.045	Double	2.6875	7550	5685	86.78	Sur.Re,Co,Int,Ad-Ti	Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
93	0.087,2x.046	Double	2.6875	7570	5444	87.01	Int,Co,Sur.Re,Ad-Ti	Grimes...[2-69]	0' = Half a 0° ply
94	0.087,2x.046	Double	2.6875	7230	5241	83.10	Sur.Re,Co,Int,Ad-Ti	Grimes...[2-69]	
95	0.087,2x.046	Double	2.6875	7450	5457	85.63	Sur.Re,Int,Co,Ad-Ti	Grimes...[2-69]	Averaged
96	0.175, 0.180	1-St.L.	5.875	1590	789	9.09	Ad-Ti, Sur.Re	Grimes...[2-69]	
97	0.172, 0.178	1-St.L.	5.875	1405	698	8.17	Ad-Ti, Sur.Re, ..	Grimes...[2-69]	
98	0.171, 0.174	1-St.L.	5.875	1480	737	8.65	Ad-Ti, Sur.Re, Ad-Bo, ..	Grimes...[2-69]	
99	0.1727, 0.1767	1-St.L.	5.875	1492	741	8.62	Ad-Ti, Sur.Re, ...	Grimes...[2-69]	Averaged
100	0.2637, 0.265	2-St.L.	4.875	5845	1581	22.17	Other	Grimes...[2-69]	
101	0.2637, 0.265	2-St.L.	4.875	5690	1538	21.58	Other	Grimes...[2-69]	
102	0.2637, 0.265	2-St.L.	4.875	4675	1266	17.73	Other	Grimes...[2-69]	
103	0.2637, 0.265	2-St.L.	4.875	5403	1462	20.49	Other	Grimes...[2-69]	Averaged
104	0.260, 0.264	2-St.L.	5.6875	9660	2488	37.15	Sur.Re, Int, Ad-Bo	Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
105	0.260, 0.264	2-St.L.	5.6875	11850	3038	45.58	Int, Sur.Re, ...	Grimes...[2-69]	
106	0.268, 0.264	2-St.L.	5.6875	12100	3108	45.15	Int, Sur.Re, ...	Grimes...[2-69]	
107	0.260, 0.264	2-St.L.	5.6875	10975	2826	42.21	Int,Ad-Bo,Co,Sur.Re	Grimes...[2-69]	
108	0.262, 0.264	2-St.L.	5.6875	11146	2864	42.54	Int,Sur.Re,Ad-Bo, ...	Grimes...[2-69]	Averaged
109	0.046	Single	7.625	7600	4383	165.22	Other	Grimes...[2-69]	
110	0.046	Single	7.625	8430	4572	183.26	Int,Co,Sur.Re	Grimes...[2-69]	
111	0.046	Single	7.625	7590	4127	165.00	Other	Grimes...[2-69]	
112	0.046	Single	7.625	7873	4361	171.15	Int, Co, Sur.Re, ...	Grimes...[2-69]	Averaged
113	0.046	Single	6.875	4715	2353	102.50	Other	Grimes...[2-69]	0' = Half a 0° ply
114	0.046	Single	6.875	4750	2361	103.26	Other	Grimes...[2-69]	
115	0.046	Single	6.875	4810	2381	104.57	Other	Grimes...[2-69]	
116	0.046	Single	6.875	4758	2365	103.43	Other	Grimes...[2-69]	Averaged
117	0.032	Double	4.625	4070	2686	127.19	Other	Grimes...[2-69]	
118	0.031	Double	4.625	4060	2680	130.97	Other	Grimes...[2-69]	
119	0.031	Double	4.625	4320	2643	139.35	Other	Grimes...[2-69]	
120	0.031	Double	4.625	4150	2736	133.87	Other	Grimes...[2-69]	Averaged
121	0.087	Double	4.6250	6200	4088	71.26		Grimes...[2-69]	
122	0.087	Double	4.6250	5750	3784	66.09		Grimes...[2-69]	
123	0.087	Double	4.6250	5745	3127	66.03		Grimes...[2-69]	
124	0.087	Double	4.6250	5898	4000	67.79		Grimes...[2-69]	Averaged
125	0.089	Double	5.1875	8890	3510	99.89		Grimes...[2-69]	(Q45/QV-45)q-(Q45/QV-45M5/QV-45/Q)
126	0.09	Double	5.1875	7695	3044	85.50		Grimes...[2-69]	0' = Half a 0° ply
127	0.089	Double	5.1875	9560	3774	107.42		Grimes...[2-69]	
128	0.09	Double	5.1875	8715	3443	96.83		Grimes...[2-69]	Averaged
129	0.032, 0.032	Single	3.6250	4170	2472	130.31		Grimes...[2-69]	
130	0.031, 0.032	Single	3.6250	4170	2469	134.52		Grimes...[2-69]	

## Adhesive Lap-J

	A	B	C	D	E	F	G
131	AF-126-2	0.0045	1.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
132	AF-126-2	0.0042	1.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
133	AF-126-2	0.0035	2.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.005
134	AF-126-2	0.0025	2.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.005
135	AF-126-2	0.0035	2.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.004
136	AF-126-2	0.0032	2.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.005
137	AF-126-2	0.0005	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.007
138	AF-126-2	0.0000	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.006
139	AF-126-2	0.0000	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.005
140	AF-126-2	0.0002	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.006
141	AF-126-2	0.0005	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.007
142	AF-126-2	0.0012	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.007
143	AF-126-2	0.0010	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.006
144	AF-126-2	0.0009	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.007
145	AF-126-2	0.0015	2 x 0.125	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.007
146	AF-126-2	0.0020	2 x 0.125	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.007
147	AF-126-2	0.0018	2 x 0.125	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.008
148	AF-126-2	0.0018	2 x 0.125	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.007
149	AF-126-2	0.0053	2.062	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	4 x [90]9	1.003
150	AF-126-2	0.0063	1.998	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	4 x [90]9	1.003
151	AF-126-2	0.0060	1.848	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	4 x [90]9	1.001
152	AF-126-2	0.0009	1.969	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	4 x [90]9	1.002
153	MB-329	0.0050	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.019
154	MB-329	0.0040	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.018
155	MB-329	0.0040	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.020
156	MB-329	0.0043	0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.018
157	MB-329	0.0065	0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.003
158	MB-329	0.0080	0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.002
159	MB-329	0.0065	0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.003
160	MB-329	0.0070	0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[(0/45/0/-45)q/0]s	1.003
161	MB-329	0.0025	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3,[0]6	1.015
162	MB-329	0.0038	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3,[0]6	1.015
163	MB-329	0.0038	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3,[0]6	1.015
164	MB-329	0.0034	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2 x [0]3,[0]6	1.015
165	MB-329	0.0100	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.013
166	MB-329	0.0065	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.016
167	MB-329	0.0062	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.016
168	MB-329	0.0078	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.016
169	MB-329	0.0090	2 x 0.187	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45)q/0]s, [(0/45/0/-45)q/0]s	1.015
170	MB-329	0.0090	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45)q/0]s, [(0/45/0/-45)q/0]s	1.015
171	MB-329	0.0080	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45)q/0]s, [(0/45/0/-45)q/0]s	1.015
172	MB-329	0.0087	2 x 0.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	2x[(0/45/0/-45)q/0]s, [(0/45/0/-45)q/0]s	1.015
173	MB-329	0.0045	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.011
174	MB-329	0.0060	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.009
175	MB-329	0.0045	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.010
176	MB-329	0.0050	0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.010
177	MB-329	0.0045	0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.008
178	AF-126-2	0.0050	0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.009
179	AF-126-2	0.0040	0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.009
180	AF-126-2	0.0045	0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0]s	1.009
181	AF-126-2	0.0068	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
182	AF-126-2	0.0055	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.016
183	AF-126-2	0.0055	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.014
184	AF-126-2	0.0058	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.015
185	AF-126-2	0.0055	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.017
186	AF-126-2	0.0052	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.014
187	AF-126-2	0.0055	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.021
188	AF-126-2	0.0054	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.017
189	AF-126-2	0.0087	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.017
190	MB-329	0.0080	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	0.961
191	MB-329	0.0072	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	1.000
192	MB-329	0.0080	2 x 0.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0]s	0.993
193	MB-329	0.0045	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.013
194	MB-329	0.0090	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.015
195	MB-329	0.0085	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper<#400, MEK	[0]8	1.013

Adhesive Lap-J

	H	I	J	K	L	M	N	O	P
131	0.011, 0.032	Single	3.6250	4165	2469	134.35		Grimes... [2-69]	
132	0.011, 0.032	Single	3.6250	4168	2470	134.45		Grimes... [2-69]	Averaged
133	0.016, 0.045	Single	3.8750	5245	2609	114.02		Grimes... [2-69]	0° = Half a 0° ply
134	0.017, 0.045	Single	3.8750	5075	2525	107.98		Grimes... [2-69]	
135	0.016, 0.045	Single	3.8750	4940	2460	107.39		Grimes... [2-69]	
136	0.017, 0.045	Single	3.8750	5087	2531	108.23		Grimes... [2-69]	Averaged
137	0.010, 2x0.016	Double	2.6250	3340	2211	111.33		Grimes... [2-69]	
138	0.010, 2x0.016	Double	2.6250	3360	2227	112.00		Grimes... [2-69]	
139	0.030, 2x0.016	Double	2.6250	3360	2229	112.00		Grimes... [2-69]	
140	0.030, 2x0.016	Double	2.6250	3353	2222	111.77		Grimes... [2-69]	Averaged
141	0.085, 2x0.045	Double	2.6875	6180	4091	72.71		Grimes... [2-69]	
142	0.084, 2x0.045	Double	2.6875	5675	3757	66.78		Grimes... [2-69]	
143	0.085, 2x0.045	Double	2.6875	5935	3933	69.82		Grimes... [2-69]	
144	0.085, 2x0.045	Double	2.6875	5930	3927	69.76		Grimes... [2-69]	Averaged
145	0.089, 2x0.045	Double	3.1250	10250	4071	115.17		Grimes... [2-69]	(045/0/-45)g-(045/0/-45)g
146	0.089, 2x0.045	Double	3.3330	9280	3686	104.27		Grimes... [2-69]	0° = Half a 0° ply
147	0.089, 2x0.045	Double	3.1250	9810	3853	110.22		Grimes... [2-69]	
148	0.089, 2x0.045	Double	3.1250	9780	3883	109.89		Grimes... [2-69]	Averaged
149	0.182, 0.178	3-St.L.	6.4375	12150	5875	148.17	Sur.Re,Ad-Ti,Co,Ad-Bo	Grimes... [2-69]	
150	0.178, 0.173	3-St.L.	6.4375	12450	6212	159.62	Sur.Re,Ad-Ti,Ad-Bo,Co	Grimes... [2-69]	
151	0.179, 0.174	3-St.L.	6.4375	10750	5811	136.08	Sur.Re,Co,Ad-Ti,Ad-Bo	Grimes... [2-69]	
152	0.1797, 0.1743	3-St.L.	6.4375	11783	5966	149.15	Sur.Re,Ad-Ti,Co,Ad-Bo	Grimes... [2-69]	Averaged
153	0.04	Single	4.3125	1075	4219	26.88	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
154	0.041	Single	4.3125	1140	4474	27.80	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
155	0.041	Single	4.3125	1010	3961	24.63	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
156	0.04	Single	4.3125	1075	4218	26.88	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	Averaged
157	0.043	Single	4.5625	855	1705	19.88	Ad-Bo,C0, Sur.Re	Grimes... [2-69]	0° = Half a 0° ply
158	0.043	Single	4.5625	870	1736	20.23	Ad-Bo,C0, Sur.Re	Grimes... [2-69]	
159	0.044	Single	4.5625	915	1824	20.80	Ad-Bo,C0, Sur.Re	Grimes... [2-69]	
160	0.043	Single	4.5625	880	1755	20.47	Ad-Bo,C0, Sur.Re	Grimes... [2-69]	Averaged
161	0.032	Double	4.25	1910	3764	59.69	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
162	0.032	Double	4.25	2265	4463	70.78	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
163	0.032	Double	4.25	2320	4571	72.50	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
164	0.032	Double	4.25	2165	4266	67.66	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	Averaged
165	0.090	Double	4.25	1715	3379	19.06	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
166	0.090	Double	4.25	1800	3543	20.00	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	
167	0.090	Double	4.25	1840	3228	18.22	Co, Sur.Re, Ad-Bo	Grimes... [2-69]	
168	0.090	Double	4.25	1718	3383	19.09	Sur.Re,Co,Ad-Bo	Grimes... [2-69]	Averaged
169	0.09	Double	4.25	2090	5506	23.22	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	(045/0/-45)g-(045/0/-45)g
170	0.092	Double	4.3125	1770	3488	19.24	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	0° = Half a 0° ply
171	0.091	Double	4.3125	2170	4276	23.85	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	
172	0.091	Double	4.3125	2010	4423	22.09	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	Averaged
173	0.031, 0.032	Single	4.3125	810	3204	27.00	Sur.Re,Int,Ad-Bo	Grimes... [2-69]	
174	0.019, 0.032	Single	2.3125	740	2934	24.67	Sur.Re,Int,Ad-Bo	Grimes... [2-69]	
175	0.010, 0.032	Single	2.3125	780	3089	26.00	Sur.Re,Int,Ad-Bo	Grimes... [2-69]	
176	0.010, 0.032	Single	2.3125	777	3076	25.90	Sur.Re,Int,Ad-Bo	Grimes... [2-69]	Averaged
177	0.043, 0.045	Single	2.3125	1020	2024	23.72	Sur.Re,Ad-Bo,Co,Int	Grimes... [2-69]	0° = Half a 0° ply
178	0.043, 0.045	Single	3.0313	980	1942	22.79	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	
179	0.043, 0.045	Single	3.0625	920	1824	21.40	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	
180	0.043, 0.045	Single	3.0625	973	1930	22.63	Ad-Bo, Sur.Re, Co	Grimes... [2-69]	Averaged
181	0.019, 0.016	Double	3.0625	2735	5389	91.17	Sur.Re,Co,Int	Grimes... [2-69]	
182	0.010, 0.016	Double	2.25	2430	4783	81.00	Sur.Re,Ad-Bo,Ad-Ti,Co	Grimes... [2-69]	
183	0.010, 0.016	Double	2.25	2770	5461	92.33	Sur.Re,Ad-Bo,Ad-Ti,Co	Grimes... [2-69]	
184	0.010, 0.016	Double	2.25	2645	5212	88.17	Sur.Re,Ad-Bo,Ad-Ti,Co	Grimes... [2-69]	Averaged
185	0.017, 0.045	Double	2.25	2345	4612	27.27	Sur.Re,Ad-Bo,Co,Int	Grimes... [2-69]	
186	0.016, 0.045	Double	2.25	2410	4753	28.02	Sur.Re,Int	Grimes... [2-69]	
187	0.015, 0.045	Double	2.25	2770	5476	32.21	Sur.Re,Int,Co	Grimes... [2-69]	
188	0.015, 0.045	Double	2.25	2508	4930	29.16	Sur.Re,Int,Ad-Bo	Grimes... [2-69]	Averaged
189	0.019, 0.045	Double	2.3125	1025	2016	11.52	Sur.Re,Ad-Ti,Co	Grimes... [2-69]	(045/0/-45)g-(045/0/-45)g
190	0.010, 0.045	Double	2.3125	1865	3881	20.96	Sur.Re,Ad-Ti,Co	Grimes... [2-69]	0° = Half a 0° ply
191	0.019, 0.045	Double	2.375	1870	3740	21.01	Sur.Re,Ad-Ti,Co	Grimes... [2-69]	
192	0.019, 0.045	Double	2.3125	1587	3212	17.83	Sur.Re,Ad-Ti,Co	Grimes... [2-69]	Averaged
193	0.041	Single	5.3125	3230	2551	78.78	Sur.Re,Co,Int	Grimes... [2-69]	
194	0.040	Single	5.3125	3100	2443	77.50	Ad-Bo,Int,Co	Grimes... [2-69]	
195	0.040	Single	5.3125	2805	2215	70.13	Sur.Re,Co,Int	Grimes... [2-69]	

	A	B	C	D	E	F	G
186	MB-329	0.0073	1.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0]8	1.014
187	MB-329	0.0110	1.500	Bo/Ep-Bo/Ep	3o: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.012
188	MB-329	0.0120	1.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.014
189	MB-329	0.0120	1.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.015
200	MB-329	0.0117	1.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.013
201	MB-329	0.0052	2 x 0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.013
202	MB-329	0.0052	2 x 0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.013
203	MB-329	0.0060	2 x 0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.011
204	MB-329	0.0050	2 x 0.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.012
205	MB-329	0.0048	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.012
206	MB-329	0.0045	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.012
207	MB-329	0.0045	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.015
208	MB-329	0.0046	2 x 0.750	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.013
209	MB-329	0.0085	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.013
210	MB-329	0.0085	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.013
211	MB-329	0.0092	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.014
212	MB-329	0.0081	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.013
213	MB-329	0.0050	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.009
214	MB-329	0.0055	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.012
215	MB-329	0.0050	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.012
216	MB-329	0.0052	1.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.011
217	MB-329	0.0040	1.437	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.013
218	MB-329	0.0040	1.437	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.012
219	MB-329	0.0030	1.437	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.014
220	MB-329	0.0037	1.437	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.013
221	MB-329	0.0040	2 x 0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.003
222	MB-329	0.0060	2 x 0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.003
223	MB-329	0.0060	2 x 0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.003
224	MB-329	0.0053	2 x 0.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.003
225	MB-329	0.0060	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.002
226	MB-329	0.0072	2 x 0.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.005
227	MB-329	0.0088	2 x 0.750	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.002
228	MB-329	0.0067	2 x 0.708	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.003
229	MB-329	0.0088	2 x 0.100	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0°)q/0°]s	1.006
230	MB-329	0.0100	2 x 0.100	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0°)q/0°]s	1.006
231	MB-329	0.0108	2 x 0.100	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0°)q/0°]s	1.004
232	MB-329	0.0099	2 x 0.100	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45/0°)q/0°]s	1.005
233	MB-329	0.0070	2.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0]8	1.008
234	MB-329	0.0070	2.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0]8	1.010
235	MB-329	0.0055	2.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0]8	1.007
236	MB-329	0.0063	2.250	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0]8	1.008
237	MB-329	0.0090	2.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.008
238	MB-329	0.0080	2.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.010
239	MB-329	0.0090	2.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.003
240	MB-329	0.0087	2.500	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	[0/45/0/-45/0°]s	1.007
241	MB-329	0.0090	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.013
242	MB-329	0.0082	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.013
243	MB-329	0.0075	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.011
244	MB-329	0.0082	2 x 0.100	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2 x [0]3,[0]6	1.012
245	MB-329	0.0082	2 x 0.150	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.011
246	MB-329	0.0072	2 x 0.150	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.010
247	MB-329	0.0072	2 x 0.150	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.014
248	MB-329	0.0069	2 x 0.150	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/90)4/0], [(0/90)8/0]	1.012
249	MB-329	0.0068	2 x 0.175	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.007
250	MB-329	0.0058	2 x 0.175	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.010
251	MB-329	0.0070	2 x 0.175	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.011
252	MB-329	0.0065	2 x 0.175	Bo/Ep-Bo/Ep	Bo: MEK, sandpaper-#400, MEK	2x[(0/45/0/-45/0°)s], [(0/45/0/-45/0°)q/0°]s	1.009
253	MB-329	0.0045	2.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	0.999
254	MB-329	0.0050	2.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
255	MB-329	0.0050	2.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
256	MB-329	0.0048	2.250	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.000
257	MB-329	0.0095	2.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.000
258	MB-329	0.0110	2.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.004
259	MB-329	0.0115	2.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.007
260	MB-329	0.0107	2.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0/45/0/-45/0°]s	1.004

Adhesive Lap-J

	H	I	J	K	L	M	N	O	P
196	0.041	Single	5.3125	3045	2403	74.27	Sur. Re, Co, Int	Grimes...[2-69]	Averaged
197	0.044	Single	5.5625	2135	1406	48.52	Ad-Bo, Co, Sur. Re	Grimes...[2-69]	0' = Half a 0" ply
198	0.044	Single	5.625	2145	1410	48.75	Ad-Bo, Co, Sur. Re	Grimes...[2-69]	
199	0.044	Single	5.625	2190	1438	49.77	Ad-Bo, Sur. Re	Grimes...[2-69]	
200	0.044	Single	5.625	2157	1418	49.02	Ad-Bo, Co, Sur. Re	Grimes...[2-69]	Averaged
201	0.031	Double	4.375	3840	3751	123.87	Ad-Bo, Sur. Re, Co	Grimes...[2-69]	
202	0.031	Double	4.375	4845	4585	149.84	Ad-Bo, Sur. Re, Co	Grimes...[2-69]	
203	0.032	Double	4.375	4415	4367	137.97		Grimes...[2-69]	
204	0.031	Double	4.375	4300	4248	138.71	Ad-Bo, Sur. Re, Co	Grimes...[2-69]	Averaged
205	0.088	Double	4.50	4950	3281	58.25	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
206	0.088	Double	4.50	4945	3258	56.19	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
207	0.088	Double	4.50	5250	3448	59.66	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
208	0.088	Double	4.50	5048	3322	57.36	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	Averaged
209	0.087	Double	4.875	4750	2344	54.60	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
210	0.085	Double	4.875	5510	2720	64.82	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
211	0.085	Double	4.875	5510	2717	64.82	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
212	0.086	Double	4.875	5257	2594	61.13	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	Averaged
213	0.032, 0.032	Single	5.1875	1905	1510	59.53	Ad-Ti, Sur. Re, Co, Ad-Bo, Int	Grimes...[2-69]	
214	0.031, 0.032	Single	5.1875	1915	1514	59.84	Sur. Re, Ad-Ti, Co, Ad-Bo	Grimes...[2-69]	
215	0.032, 0.032	Single	5.1875	2050	1620	64.06	Sur. Re, Ad-Ti, Co, Ad-Bo	Grimes...[2-69]	
216	0.032, 0.032	Single	5.1875	1957	1548	61.16	Sur. Re, Ad-Ti, Co, Ad-Bo	Grimes...[2-69]	Averaged
217	0.043, 0.045	Single	5.4375	1960	1346	45.58	Sur. Re, Int, Co	Grimes...[2-69]	
218	0.043, 0.045	Single	5.4375	2070	1423	48.14	Sur. Re, Int, Co, Ad-Bo, Ad-Ti	Grimes...[2-69]	
219	0.043, 0.045	Single	5.4375	2250	1544	52.33	Sur. Re, Int, Co, Ad-Bo, Ad-Ti	Grimes...[2-69]	
220	0.043, 0.045	Single	5.4375	2093	1438	48.67	Sur. Re, Int, Co	Grimes...[2-69]	Averaged
221	0.030, 2x0.016	Double	3.375	1210	1206	39.03	Co, Ad-Ti, Sur. Re	Grimes...[2-69]	
222	0.031, 2x0.016	Double	3.375	1350	1348	43.55	Co, Ad-Ti, Sur. Re	Grimes...[2-69]	
223	0.032, 2x0.016	Double	3.375	1430	1426	46.13	Co, Ad-Ti, Sur. Re	Grimes...[2-69]	
224	0.031, 2x0.016	Double	3.375	1330	1326	42.90	Co, Ad-Ti, Sur. Re	Grimes...[2-69]	Averaged
225	0.080, 2x0.045	Double	2.75	4955	3599	55.06	Int, Sur. Re, Ad-Ti, Co	Grimes...[2-69]	
226	0.089, 2x0.045	Double	2.8125	4515	3270	50.17	Int, Ad-Ti, Sur. Re	Grimes...[2-69]	
227	0.090, 2x0.045	Double	2.8125	4640	3087	51.56	Int, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	
228	0.090, 2x0.045	Double	2.8125	4703	3319	52.26	Int, Ad-Ti, Sur. Re, Ad-Bo	Grimes...[2-69]	Averaged
229	0.089, 2x0.045	Double	3.00	5070	2520	56.97	Sur. Re, Ad-Ti, Co, Int	Grimes...[2-69]	
230	0.089, 2x0.045	Double	3.00	5300	2634	59.55	Sur. Re, Ad-Ti, Co	Grimes...[2-69]	
231	0.088, 2x0.045	Double	3.00	5210	2595	58.54	Sur. Re	Grimes...[2-69]	
232	0.089, 2x0.045	Double	3.00	5193	2455	58.35	Sur. Re, Ad-Ti, Co	Grimes...[2-69]	Averaged
233	0.041	Single	6.00	5150	2271	125.61	Sur. Re, Co, Int	Grimes...[2-69]	
234	0.041	Single	6.00	5205	2290	126.95	Sur. Re, Co, Int	Grimes...[2-69]	
235	0.041	Single	6.00	4350	1920	106.10	Sur. Re, Co, Int	Grimes...[2-69]	
236	0.041	Single	6.00	4902	2160	119.56	Sur. Re, Co, Int	Grimes...[2-69]	Averaged
237	0.048	Single	6.375	2760	1625	57.50	Ad-Bo, Sur. Re	Grimes...[2-69]	0' = Half a 0" ply
238	0.047	Single	6.375	3020	1188	64.26	Ad-Bo, Sur. Re, Int	Grimes...[2-69]	
239	0.048	Single	6.375	3350	1336	69.79	Ad-Bo, Sur. Re, Int	Grimes...[2-69]	
240	0.047	Single	6.375	3043	1209	64.74	Ad-Bo, Sur. Re	Grimes...[2-69]	Averaged
241	0.030	Double	4.875	3555	1755	118.50	Sur. Re, Ad-Bo, Co	Grimes...[2-69]	
242	0.030	Double	4.875	4150	2048	138.33	Int	Grimes...[2-69]	
243	0.030	Double	4.875	4330	2141	144.33	Int, Sur. Re, Co, Ad-Bo	Grimes...[2-69]	
244	0.030	Double	4.875	4012	1981	133.73	Int, Sur. Re, Ad-Bo, Co	Grimes...[2-69]	Averaged
245	0.09	Double	5.3125	5200	1714	57.78	Ad-Bo, Sur. Re, Co	Grimes...[2-69]	
246	0.088	Double	5.3125	5275	1741	59.94	Ad-Bo, Int, Sur. Re	Grimes...[2-69]	
247	0.087	Double	5.3125	4245	1395	48.79	Ad-Bo, Int, Sur. Re	Grimes...[2-69]	
248	0.088	Double	5.3125	4907	1617	55.76	Ad-Bo, Int, Sur. Re	Grimes...[2-69]	Averaged
249	0.087	Double	5.50	4770	1353	54.83	Ad-Bo, Sur. Re	Grimes...[2-69]	(0450/45)-(0450/45)(0450/45/0)
250	0.089	Double	5.50	4080	1154	45.84	Ad-Bo, Sur. Re	Grimes...[2-69]	0' = Half a 0" ply
251	0.087	Double	5.50	6370	1800	73.22	Ad-Bo, Sur. Re	Grimes...[2-69]	
252	0.088	Double	5.50	5073	1436	57.65	Ad-Bo, Sur. Re	Grimes...[2-69]	Averaged
253	0.032, 0.032	Single	4.25	3065	1364	95.78	Sur. Re, Ad-Ti, Co, Int	Grimes...[2-69]	
254	0.032, 0.032	Single	4.25	2840	1262	88.75	Sur. Re, Ad-Ti, Co, Int, Ad-Bo	Grimes...[2-69]	
255	0.032, 0.032	Single	4.25	2460	1093	76.88	Sur. Re, Ad-Ti, Co, Int, Ad-Bo	Grimes...[2-69]	
256	0.032, 0.032	Single	4.25	2788	1240	87.13	Sur. Re, Ad-Ti, Co, Int	Grimes...[2-69]	Averaged
257	0.047, 0.045	Single	4.5625	1870	748	38.96	Ad-Bo, Sur. Re	Grimes...[2-69]	0' = Half a 0" ply
258	0.048, 0.045	Single	4.5625	2325	926	48.44	Ad-Bo, Sur. Re, Ad-Ti, Int	Grimes...[2-69]	
259	0.048, 0.045	Single	4.5625	2450	973	51.04	Sur. Re, Ad-Bo, Ad-Ti, Int	Grimes...[2-69]	
260	0.048, 0.045	Single	4.5625	2215	882	46.15	Ad-Bo, Sur. Re, Ad-Ti, Int	Grimes...[2-69]	Averaged

	A	B	C	D	E	F	G
261	MB-329	0.0053	2 x 1.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]8	1.005
262	MB-329	0.0055	2 x 1.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.007
263	MB-329	0.0055	2 x 1.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.006
264	MB-329	0.0056	2 x 1.000	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[0]6	1.006
265	MB-329	0.0055	2 x 1.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.007
266	MB-329	0.0060	2 x 1.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.009
267	MB-329	0.0060	2 x 1.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.009
268	MB-329	0.0058	2 x 1.500	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/90)8/0]	1.008
269	MB-329	0.0068	2 x 1.718	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0's	1.009
270	MB-329	0.0055	2 x 1.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0's	1.010
271	MB-329	0.0072	2 x 1.687	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0's	1.010
272	MB-329	0.0065	2 x 1.697	Bo/Ep-Ti	Ti: Grit blast, Oakite 31, 841ml HCL acid	[(0/45/0/-45)q/0's	1.010
273	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	1.001
274	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
275	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	1.000
276	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	1.000
277	EA 951 Film		1.00	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.760
278	EA 951 Film		1.00	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.755
279	EA 951 Film		1.00	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.760
280	EA 951 Film		1.00	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.758
281	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
282	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
283	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
284	EA 951 Film		0.50	Gr/Ep-Ti	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
285	EA 951 Film		0.50	Gr/Ep-Gr/Ep	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	1.002
286	EA 951 Film		0.50	Gr/Ep-Gr/Ep	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.995
287	EA 951 Film		0.50	Gr/Ep-Gr/Ep	Grit blasted-AL oxide pow., air blast	[0±45/90]2s	0.999
288	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
289	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
290	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
291	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
292	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
293	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
294	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
295	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
296	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
297	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
298	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
299	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
300	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
301	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
302	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
303	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
304	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
305	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
306	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
307	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
308	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
309	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
310	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
311	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
312	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
313	EC-2214-R	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
314	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
315	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
316	EC-2214-R	0.010	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
317	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
318	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
319	EC-2214-R	0.020	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
320	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
321	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
322	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
323	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
324	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00
325	FM-123-5	0.005	0.50	SVSt 4340	Chlorinated hydrocarbon,sandblast, Freon	isotropic	1.00

## Adhesive Lap-J

	H	I	J	K	L	M	N	O	P
261	0.031, 2x0.016	Double	2.75	4385	2181	146.17	Sur.Re,Ad-Ti,Ad-Bo,Int	Grimes...[2-69]	
262	0.030, 2x0.016	Double	2.75	4320	2145	144.00	Int	Grimes...[2-69]	
263	0.030, 2x0.016	Double	2.75	4475	2224	149.17	Sur. Re, Ad-Bo, Co,Int	Grimes...[2-69]	
264	0.030, 2x0.016	Double	2.75	4393	2183	146.43	Int, Sur. Re, Ad-Bo	Grimes...[2-69]	Averaged
265	0.089, 2x0.045	Double	3.4375	4205	1392	47.25	Sur.Re,Ad-Bo,Int,Co	Grimes...[2-69]	
266	0.088, 2x0.045	Double	3.4375	5740	1896	64.49	Ad-Bo,...	Grimes...[2-69]	
267	0.088, 2x0.045	Double	3.4375	5045	1667	56.69	Int,Sur.Re,Ad-Bo,Ad-Ti,Co	Grimes...[2-69]	
268	0.089, 2x0.045	Double	3.4375	4997	1652	56.15	Sur.Re,Ad-Bo,Int	Grimes...[2-69]	Averaged
269	0.089, 2x0.045	Double	3.6875	3715	1072	41.74	Ad-Ti, Sur. Re, Int	Grimes...[2-69]	0° - Half a 0° ply
270	0.080, 2x0.045	Double	3.6875	4385	1287	49.27	Sur. Re, Ad-Ti, Ad-Bo	Grimes...[2-69]	
271	0.090, 2x0.045	Double	3.6875	3860	1133	43.37	Ad-Ti, Sur. Re, Int	Grimes...[2-69]	
272	0.090, 2x0.045	Double	3.6875	3987	1164	44.80	Ad-Ti, Sur. Re, Int	Grimes...[2-69]	Averaged
273	0.128, 0.042	Single	4.00	2630	5250	20.55	45-ply, Ad, 0-ply	Kelly [2-70]	Ti: Ti 6AL4V
274	0.128, 0.042	Single	4.00	2720	5450	21.25	0-ply, Ad, 45-ply	Kelly [2-70]	CARBOFORM, Ep:ERLA 4617/DDM
275	0.128, 0.042	Single	4.00	2250	4500	17.58	Ad, 0-ply, 45-ply	Kelly [2-70]	
276	0.128, 0.042	Single	4.00	2535	5070	19.80	Ad, 0-ply, 45-ply	Kelly [2-70]	Averaged
277	0.128, 2x0.042	Double	3.50	8039	4020	62.80	0-ply, Ad	Kelly [2-70]	Ti: Ti 6AL4V
278	0.128, 2x0.042	Double	3.50	5470	2735	42.73	Tens, Delamination	Kelly [2-70]	CARBOFORM, Ep:ERLA 4617/DDM
279	0.128, 2x0.042	Double	3.50	7960	3980	62.19	0-ply, 45-ply, Ad	Kelly [2-70]	
280	0.128, 2x0.042	Double	3.50	7158	3580	55.91	0-ply, Ad, Tens	Kelly [2-70]	Averaged
281	0.128, 2x0.042	Double	4.00	5800	5805	45.31	0-ply, Ad	Kelly [2-70]	Ti: Ti 6AL4V
282	0.128, 2x0.042	Double	4.00	5200	5205	40.63	0-ply, Ad	Kelly [2-70]	CARBOFORM, Ep:ERLA 4617/DDM
283	0.128, 2x0.042	Double	4.00	4360	4360	34.06	Ad, 0-ply	Kelly [2-70]	
284	0.128, 2x0.042	Double	4.00	5119	5125	39.99	0-ply, Ad	Kelly [2-70]	Averaged
285	0.128, 0.042	Single	4.00	2730	5450	21.33	0-ply, Ad	Kelly [2-70]	CARBOFORM, Ep:ERLA 4617/DDM
286	0.128, 0.042	Single	4.00	2860	5750	22.34	0-ply, Ad	Kelly [2-70]	
287	0.128, 0.042	Single	4.00	2795	5600	21.84	0-ply, Ad	Kelly [2-70]	Averaged
288	0.005	Single	10.5(T.L.)	1500	3000	300.00		Guess...[2-39]	ASTM D1002-72
289	0.005	Single	10.5(T.L.)	1590	3180	318.00		Guess...[2-39]	Averaged of 3 or more tests
290	0.005	Single	10.5(T.L.)	1655	3310	331.00		Guess...[2-39]	Averaged of 3 or more tests
291	0.005	Single	10.5(T.L.)	1525	3050	305.00		Guess...[2-39]	Averaged of 3 or more tests
292	0.005	Single	10.5(T.L.)	1570	3140	314.00		Guess...[2-39]	Averaged of 3 or more tests
293	0.25	Single	3.75(p-p)	4000	8000	16.00		Guess...[2-39]	Thick adherand test
294	0.25	Single	3.75(p-p)	3790	7580	15.16		Guess...[2-39]	Averaged of 3 or more tests
295	0.25	Single	3.75(p-p)	4030	8060	16.12		Guess...[2-39]	Averaged of 3 or more tests
296	0.25	Single	3.75(p-p)	3900	7800	15.60		Guess...[2-39]	Averaged of 3 or more tests
297	0.25	Single	3.75(p-p)	3940	7880	15.76		Guess...[2-39]	Averaged of 3 or more tests
298	0.25	Single	3.75(p-p)	3930	7860	15.72		Guess...[2-39]	Averaged of 3 or more tests
299	0.25	Single	3.75(p-p)	3700	7400	14.80		Guess...[2-39]	Averaged of 3 or more tests
300	0.25	Single	3.75(p-p)	3750	7500	15.00		Guess...[2-39]	Averaged of 3 or more tests
301	0.25	Single	3.75(p-p)	3710	7420	14.84		Guess...[2-39]	Averaged of 3 or more tests
302	0.50	Single	3.75(p-p)	4180	8360	8.36		Guess...[2-39]	Thick adherand test
303	0.50	Single	3.75(p-p)	4310	8620	8.62		Guess...[2-39]	Averaged of 3 or more tests
304	0.50	Single	3.75(p-p)	4320	8640	8.64		Guess...[2-39]	Averaged of 3 or more tests
305	0.50	Single	3.75(p-p)	4230	8460	8.46		Guess...[2-39]	Averaged of 3 or more tests
306	0.50	Single	3.75(p-p)	4180	8360	8.36		Guess...[2-39]	Averaged of 3 or more tests
307	0.50	Single	3.75(p-p)	4160	8320	8.32		Guess...[2-39]	Averaged of 3 or more tests
308	0.50	Single	3.75(p-p)	4060	8120	8.12		Guess...[2-39]	Averaged of 3 or more tests
309	0.50	Single	3.75(p-p)	4000	8000	8.00		Guess...[2-39]	Averaged of 3 or more tests
310	0.50	Single	3.75(p-p)	4150	8300	8.30		Guess...[2-39]	Averaged of 3 or more tests
311	1.00	Single	3.75(p-p)	4290	8580	4.29		Guess...[2-39]	Thick adherand test
312	1.00	Single	3.75(p-p)	4450	8900	4.45		Guess...[2-39]	Averaged of 3 or more tests
313	1.00	Single	3.75(p-p)	4280	8560	4.28		Guess...[2-39]	Averaged of 3 or more tests
314	1.00	Single	3.75(p-p)	4220	8440	4.22		Guess...[2-39]	Averaged of 3 or more tests
315	1.00	Single	3.75(p-p)	4170	8340	4.17		Guess...[2-39]	Averaged of 3 or more tests
316	1.00	Single	3.75(p-p)	4290	8580	4.29		Guess...[2-39]	Averaged of 3 or more tests
317	1.00	Single	3.75(p-p)	4000	8000	4.00		Guess...[2-39]	Averaged of 3 or more tests
318	1.00	Single	3.75(p-p)	4000	8000	4.00		Guess...[2-39]	Averaged of 3 or more tests
319	1.00	Single	3.75(p-p)	4100	8200	4.10		Guess...[2-39]	Averaged of 3 or more tests
320	0.005	Single	10.5(T.L.)	2290	4580	458.00		Guess...[2-39]	ASTM D1002-72
321	0.005	Single	10.5(T.L.)	2300	4600	460.00		Guess...[2-39]	Averaged of 3 or more tests
322	0.005	Single	10.5(T.L.)	2350	4700	470.00		Guess...[2-39]	Averaged of 3 or more tests
323	0.005	Single	10.5(T.L.)	2340	4680	468.00		Guess...[2-39]	Averaged of 3 or more tests
324	0.005	Single	10.5(T.L.)	2330	4660	466.00		Guess...[2-39]	Averaged of 3 or more tests
325	0.25	Single	3.75(p-p)	2910	5820	11.64		Guess...[2-39]	Thick adherand test

[illegible]

Adhesive Lap-J

	H	I	J	K	L	M	N	O	P
326	0.25	Single	3.75(p-p)	3090	6180	12.38		Guess...[2-39]	Averaged of 3 or more tests
327	0.25	Single	3.75(p-p)	2710	5420	10.84		Guess...[2-39]	Averaged of 3 or more tests
328	0.25	Single	3.75(p-p)	2800	5600	11.20		Guess...[2-39]	Averaged of 3 or more tests
329	0.25	Single	3.75(p-p)	2650	5300	10.60		Guess...[2-39]	Averaged of 3 or more tests
330	0.25	Single	3.75(p-p)	2320	4640	9.28		Guess...[2-39]	Averaged of 3 or more tests
331	0.25	Single	3.75(p-p)	2710	5420	10.84		Guess...[2-39]	Averaged of 3 or more tests
332	0.25	Single	3.75(p-p)	2620	5240	10.48		Guess...[2-39]	Averaged of 3 or more tests
333	0.25	Single	3.75(p-p)	2300	4600	9.20		Guess...[2-39]	Averaged of 3 or more tests
334	0.50	Single	3.75(p-p)	3000	6000	6.00		Guess...[2-39]	Thick adherand test
335	0.50	Single	3.75(p-p)	2760	5520	5.52		Guess...[2-39]	Averaged of 3 or more tests
336	0.50	Single	3.75(p-p)	2850	5700	5.70		Guess...[2-39]	Averaged of 3 or more tests
337	0.50	Single	3.75(p-p)	2790	5580	5.58		Guess...[2-39]	Averaged of 3 or more tests
338	0.50	Single	3.75(p-p)	2790	5580	5.58		Guess...[2-39]	Averaged of 3 or more tests
339	0.50	Single	3.75(p-p)	2480	4960	4.96		Guess...[2-39]	Averaged of 3 or more tests
340	0.50	Single	3.75(p-p)	2750	5500	5.50		Guess...[2-39]	Averaged of 3 or more tests
341	0.50	Single	3.75(p-p)	2640	5280	5.28		Guess...[2-39]	Averaged of 3 or more tests
342	0.50	Single	3.75(p-p)	2490	4980	4.98		Guess...[2-39]	Averaged of 3 or more tests
343	0.50	Single	3.75(p-p)	2500	5000	5.00		Guess...[2-39]	Averaged of 3 or more tests
344	0.50	Single	3.75(p-p)	2420	4840	4.84		Guess...[2-39]	Averaged of 3 or more tests
345	1.00	Single	3.75(p-p)	2960	5920	2.96		Guess...[2-39]	Thick adherand test
346	1.00	Single	3.75(p-p)	2790	5580	2.79		Guess...[2-39]	Averaged of 3 or more tests
347	1.00	Single	3.75(p-p)	2760	5520	2.76		Guess...[2-39]	Averaged of 3 or more tests
348	1.00	Single	3.75(p-p)	2840	5680	2.84		Guess...[2-39]	Averaged of 3 or more tests
349	1.00	Single	3.75(p-p)	2600	5200	2.60		Guess...[2-39]	Averaged of 3 or more tests
350	1.00	Single	3.75(p-p)	2500	5000	2.50		Guess...[2-39]	Averaged of 3 or more tests
351	1.00	Single	3.75(p-p)	2340	4680	2.34		Guess...[2-39]	Averaged of 3 or more tests
352	1.00	Single	3.75(p-p)	2730	5460	2.73		Guess...[2-39]	Averaged of 3 or more tests
353	1.00	Single	3.75(p-p)	2430	4860	2.43		Guess...[2-39]	Averaged of 3 or more tests
354	1.00	Single	3.75(p-p)	2490	4980	2.49		Guess...[2-39]	Averaged of 3 or more tests

**Appendix C-1. Mechanical properties of composite laminae.**

Lamina Properties

A		B	C		D		E		F		G		H		I		J		K
1	Material	Fiber	Fiber	Volume	Test	Moisture	Longitudinal	Transverse	Shear	Poisson's	Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal
2	Fiber/Resin	Form	Volume	Fraction %	ture °F	Content	Modulus	Modulus	Modulus	Ratio	Tensile	Strength, X ksi	Strength, X ksi	Strength, X ksi	Strength, X ksi	Strength, X ksi	Strength, X ksi	Strength, X ksi	Strength, X ksi
3						% wt	E11, Msi	E22, Msi	G12, Msi										
4	Gr/Ep AS4/3502	Unidirect.		61.5	75	0	20.87	1.72	0.97	0.326	270	215							
5	Gr/Ep AS4/3501-6	Unidirect.		61.5	75	0	20.16	1.61	0.69	0.27									
6	Gr/Ep T300/834	Unidirect.			75	0	20.0	1.7	0.66	0.29									
7	Gr/Ep Scotchply 1002	Unidirect.			75		6.05	1.89	0.49	0.3									
8	Gr/Ep Scotchply 1002	Unidirect.			75														
9	Gr/PEEK AS4/APC-2	Unidirect.			75	0	19.44	1.29	0.74	0.28	308.9								
10	Gr/PEEK XAS/APC-1	Unidirect.			75	0	17.56	1.47	0.67	0.37	263.6								
11	Gr/PEEK AS4/PEEK	Unidirect.			75		18.51	1.49	0.87	0.32	308.9								
12	Gr/PEEK AS4/PEEK	Unidirect.			150		18.78	1.39	0.78	0.33	311.3								
13	Gr/PEEK AS4/PEEK	Unidirect.			250		18.59	1.20	0.71	0.32	302.4								
14	Gr/PEEK AS4/PEEK	Unidirect.			350		18.49	0.71	0.41	0.34	293.3								
15	Gr/PEEK AS4/PEEK	Unidirect.			75		19.69				236.4								
16	Gr/Ep T300/914	Unidirect.			75		17.57				208.9								
17	Gr/Ep AS1/3501-6	Unidirect.			75		18.85	1.9	0.85	0.30	230	321							
18	Gr/Ep AS1/3501-6	Unidirect.			75	0.86	18.85	1.72	0.77	0.30	230	231							
19	Gr/Ep AS1/3501-6	Unidirect.			250	0.86	18.54	1.27	0.60	0.30	236	151							
20	Gr/Ep Scotchply 1002S	Unidirect.			75		7.18				261.6								
21	Gr/Ep Scotchply 1002S	Unidirect.			75		7.59				255.0								
22	Gr/Ep Scotchply 1002S	Unidirect.			75		6.69				203.2								
23	Gr/Ep Scotchply 1002S	Unidirect.			160		6.54				177.1								
24	Gr/Ep Scotchply 1002S	Unidirect.			-65		7.00				77.7								
25	Gr/Ep XP251S	Unidirect.			75		7.67				247								
26	Gr/Ep XP251S	Unidirect.			160		7.69				231.9								
27	Gr/Ep XP251S	Unidirect.			-65		8.10				62.36								
28	Gr/Ep XP251S	Unidirect.			75		8.33				143.6								
29	Gr/Ep 143S/8P907	Woven			75		5.31				165.5								
30	Gr/Ep 143S/8P907	Woven			75		4.50				139.7								
31	Gr/Ep 143S/8P907	Woven			75		4.47				121.3								
32	Gr/Ep 143S/8P907	Woven			160		3.81				115.1								
33	Gr/Ep 143S/8P907	Woven			-65		5.20				78.7								
34	Gr/Ep XP251S	Unidirect.			75		8.44				209.2								
35	Gr/Ep XP251S	Unidirect.			75		8.50				146.4								
36	Gr/Ep T300/1034-C	Unidirect.			75		21.3	1.65	0.89	0.3	251	200							
37	S-Gr/Ep SP-250/Ep	Unidirect.			75		6.65	1.86	0.74	0.29	199.5	170							

Lamina Properties

	L	M	N	O	P	Q	R	S	T	U
1	Transverse	Transverse	Shear	Longitudinal	Longitudinal	Transverse	Transverse	Thermal	Thermal	Reference
2	Tensile	Compression	Strength	Tensile Ult.	Compress. Ult.	Tensile Ult.	Compress. Ult.	Expansion Coeff	Expansion Coeff	
3	Strength, Y ksi	Strength, Y ksi	S, ksi	Strain %	Strain %	Strain %	Strain %	a11(E-6)/°C	a22(E-6)/°C	
4	7.5	30	9.4					-0.899	23.0	Tan [3-1]
5								0.36	26.8	Tan [3-2]
6								0.05	16	Flags [3-3]
7										Highsmith... [3-4]
8								7.43	22.4	Pagano, Hahn [3-5]
9	11.6	29.0	23.2							Tan [3-6]
10	12.6	31.4	21.4							Tan [3-6]
11	13.8		11.9							Yoon, Sun [3-7]
12	12.3		9.9							Yoon, Sun [3-7]
13	9.4		7.7							Yoon, Sun [3-7]
14	5.8		5.2							Yoon, Sun [3-7]
15				1.16						Henaff-Gardin [3-8]
16				1.19						Henaff-Gardin [3-8]
17	9.5	38.9	17.3	1.22	1.76	0.54	2.91			Garbo, Ogonowski [3-9]
18		35.2	17.3	1.22	1.27					Garbo, Ogonowski [3-9]
19		26.0	11.0	1.27	0.83					Garbo, Ogonowski [3-9]
20										Cutler, Pinckney [3-10]
21										Cutler, Pinckney [3-10]
22										Cutler, Pinckney [3-10]
23										Cutler, Pinckney [3-10]
24										Cutler, Pinckney [3-10]
25										Cutler, Pinckney [3-10]
26										Cutler, Pinckney [3-10]
27										Cutler, Pinckney [3-10]
28										Cutler, Pinckney [3-10]
29										Cutler, Pinckney [3-10]
30										Cutler, Pinckney [3-10]
31										Cutler, Pinckney [3-10]
32										Cutler, Pinckney [3-10]
33										Cutler, Pinckney [3-10]
34										Cutler, Pinckney [3-10]
35										Cutler, Pinckney [3-10]
36	9.65	38.9	19.4							Chang, Chang [3-11]
37	8.59	30.0	13.8							Serbian, Op. [3-12]

Lamira Properties

	A	B	C	D	E	F	G	H	I	J	K
38	Gr/Ep T300/N5208	Unidirect.		75		19.44	1.67	0.89	0.38	203.7	197.1
39	Gr/Ep S-1014/N5208	Unidirect.		75		8.3	2.9	0.86	0.26	289.0	170.0
40	Gr/Ep 1062/E-773FR	Unidirect.		75		5.78				153	
41	Gr/Ep 104 Scrim/5505	Unidirect.		75		3.2	1.7	0.93	0.15	37.8	45.4
42	Gr/Ep 1581/N5505	Fabric		75		4.78				56.72	
43	Bo/Ep Boron/N5505	Unidirect.	53.6, [0]3	75		26.77		22.06	0.21	122.5	
44	Bo/Ep Boron/N5505	Unidirect.	49.8, [0]6	75		27.68		25.31	0.21	146.7	
45	Bo/Ep Boron/N5505	Unidirect.	51.2, [0]9	75		29.54				177.4	
46	Bo/Ep Boron/N5505	Unidirect.	50.1, [0]6	75		28.31				147.7	
47	Gr/PPS AS4/PPS	Unidirect.	56	75		22.6				333.0	195.3
48	Gr/PEEK	Unidirect.	62	75		16.2				245.0	95.5
49	Gr/Ep T300/976	Unidirect.	62	75		21.0				230.0	190.8
50	IM6/F584 Tape	Unidirect.		75		23.0	1.25	0.7	0.33	343.4	202.7
51	IM6/F584 Cloth	Unidirect.		75		10.1	10.1	0.55	0.071	142.8	86.4
52	E-GVF584 Ep	Unidirect.		75		2.1	2.1	0.7	0.18	51.0	65.3
53	S-GVF584 Ep	Unidirect.		75		3.1	3.6	0.7	0.18	120.0	150
54	Gr/Ep GI/69	Unidirect.	67	75		7.98	3.77			159.5	130.3
55	Gr/Ep GI/69	Unidirect.		75				0.73	0.23		
56	Gr/Ep GI/913	Unidirect.	60	75						169.7	
57	Gr/Ep GI/913	Unidirect.		75		6.09	2.18		0.227		108.8
58	Gr/Ep XAS/913	Unidirect.	60	75						304.6	
59	Gr/Ep XAS/913	Unidirect.		75		21.76	1.38		0.263		174
60	Gr/Ep XAS/914	Unidirect.	60	75							195.1
61	Gr/Ep HTS/914	Unidirect.	60	75							174
62	Gr/Ep HTS/H3501	Unidirect.	60	75							179.3
63	Gr/PEEK IM7/PEEK	Unidirect.	62.3	75		22.1	1.31	0.71	0.33	362.4	131.7
64	Gr/Ep AS4/3502	Unidirect.		75		20.5	1.47	0.83	0.31	246.0	Buckling
65	Gr/Ep AS4/3502	Unidirect.		250		19.7	1.27	0.75	0.30	222.0	Buckling
66	Gr/Ep AS4/3502	Unidirect.		75		21.0	1.39	0.69	0.31	326.0	
67	Gr/PEEK AS4/APC-2	Unidirect.		75		20.0				300	175
68	Gr/PEEK IM6/APC-2	Unidirect.		75		24.5				390	160
69	Gr/PEEK IM7/APC-2	Unidirect.		75		24.5				420	160
70	Gr/PEEK IM8/APC-2	Unidirect.		75		27.1				390	170
71	Gr/PEEK CF/PEEK	Unidirect.		75		19.5				300	155
72	Gr/PEEK S-2/APC-2	Unidirect.		75		8.0				170	160
73	Gr/Ep AS4/3501-6	Unidirect.	62	75	0.0	20.0				230.2	
74	Gr/Ep AS4/3502	Unidirect.	62	75	0.0	21.5				280.2	

Lamina Properties

	L	M	N	O	P	Q	R	S	T	U
38	5.92	20.65	13.3							Hart-Smith [3-13]
39	11.0	29.0	9.0							Hart-Smith [3-13]
40										Poulios [3-14]
41	13.4		11.1					10.44	17.09	Grimes... [3-15]
42										Grimes... [3-15]
43	97.8									Grimes... [3-15]
44	127.9									Grimes... [3-15]
45	174.6									Grimes... [3-15]
46	120.1									Grimes... [3-15]
47			19.8							Ong... [3-16]
48			3.17							Ong... [3-16]
49			14.7							Ong... [3-16]
50	7.1	37.4	20.2							Black... [3-17]
51	142.8	86.4	16.7							Black... [3-17]
52	51.0	65.3	16.7							Black... [3-17]
53	120.0	150.0	16.7							Black... [3-17]
54	8.27									Kretsis, Mathews [3-18]
55										Fothergill [3-19]
56										Kretsis, Mathews [3-18]
57	10.6	23.9								Ciba-Geigy [3-20]
58										Kretsis, Mathews [3-18]
59	8.27	22.5								Manufacturer
60										Collings [3-21]
61										Collings [3-21]
62										Collings [3-21]
63	12.2	24.3	23.3	1.52	0.64	1.03	1.80	-0.04	14.3	Silverman [3-22]
64	7.31	Buckling	13.5	1.12	Buckling	0.50	Buckling			Liechti... [3-23]
65	6.57	Buckling	11.0	1.08	Buckling	0.54	Buckling			Liechti... [3-23]
66	11.09			1.44		0.77				Allen, Harris [3-24]
67										ICI [3-25]
68										ICI [3-25]
69										ICI [3-25]
70										ICI [3-25]
71										ICI [3-25]
72										ICI [3-25]
73										Hercules [3-26]
74										Hercules [3-26]

Lamina Properties

	A	B	C	D	E	F	G	H	I	J	K
75	Gr/Ep AS4/3501-5A	Unidirect.	62	75	0.0	21.5				310.2	
76	Gr/Ep AS4/1919	Unidirect.	62	75	0.0	20.0				320.2	
77	Gr/Ep IM6/3501-6	Unidirect.	62	75	0.0	24.1				370.3	
78	Gr/Ep IM7/8551-7	Unidirect.	62	75	0.0	23.9				449.6	
79	Gr/Ep AS4/8552	Unidirect.	62	75	0.0	20.5				305.3	
80	Gr/Ep AS4/A193-P	Fabric-Plain	62	75	0.0	10				100.1	
81	Gr/Ep AS4/A280-5H	Fabric-Satin	62	75	0.0	10.4				100.1	
82	Gr/Ep AS4/A370-5H	Fabric-Satin	62	75	0.0	10.4				100.1	
83	Gr/Ep AS4/A370-8H	Fabric-Satin	62	75	0.0	10				90.1	
84	Gr/Ep IM6/16360-5H	Fabric-Satin	62	75	0.0	13.9				146.1	
85	Gr/Ep IM7/R6376	Unidirect.		75						415	260
86	Gr/Ep IM7/R6377	Unidirect.		75						410	255
87	Gr/Ep IM7/R6451	Unidirect.		75						330	220
88	Gr/Ep IM7/R6453	Unidirect.		75						390	260
89	Gr/Ep T300/Ep	Unidirect.		75		19.04		0.879			
90	Gr/Ep T300/Ep	Unidirect.		75		19.04		0.826			
91	Gr/Ep T300/Ep	Unidirect.		250		18.43		0.531			
92	Gr/Ep T300/Ep	Unidirect.		350				0.059			
93	Gr/Ep P75/Ep	Unidirect.		75		38.32		0.510			
94	Gr/Ep P75/Ep	Unidirect.		75		40.72		0.600			
95	Gr/Ep P75/Ep	Unidirect.		250		34.44		0.343			
96	Gr/Ep T300/APCO 2447-2343	Unidirect.	66.0	75				0.84			
97	Gr/Ep P75/APCO 2447-2343	Unidirect.	53.0	75				0.56			
98	Kevlar 285	0/90 weave	60.0	75		3.69					22.9
99	Gr/Ep T300/5208	Unidirect.	55.0	75		20.55					227.7
100	Gr/Ep S2-G/SP-250	Unidirect.	50.0	75		2.59					61.1
101	Ke/Polyester 281/F141	Fabric	55.7	75		4.77	4.77	0.21	0.05	73.4	21.1
102	Ke/Polyester 120/F141	Fabric	49.6	75		4.19	4.19	0.23	0.028	69.8	28.2
103	Boron/Ep	Unidirect.	50.0	75		30.0	2.7	0.7	0.21	192.0	353.0
104	Boron/Ep	Unidirect.	50.0	260		30.0	1.35	0.45	0.21	173.0	264.0
105	Boron/Ep	Unidirect.	50.0	350		29.9	1.13	0.32	0.21	157.0	116.0

Lamina Properties

	L	M	N	O	P	Q	R	S	T	U
75										Hercules [3-26]
76										Hercules [3-26]
77										Hercules [3-26]
78										Hercules [3-26]
79										Hercules [3-26]
80										Hercules [3-26]
81										Hercules [3-26]
82										Hercules [3-26]
83										Hercules [3-26]
84										Hercules [3-26]
85										Ciba-Geigy [3-27]
86										Ciba-Geigy [3-27]
87										Ciba-Geigy [3-27]
88										Ciba-Geigy [3-27]
89										Greszczuk [3-28]
90										Greszczuk [3-28]
91										Greszczuk [3-28]
92										Greszczuk [3-28]
93										Greszczuk [3-28]
94										Greszczuk [3-28]
95										Greszczuk [3-28]
96										Greszczuk [3-28]
97										Greszczuk [3-28]
98					2.6					Lamothé, Nunes [3-29]
99					1.3					Lamothé, Nunes [3-29]
100					2.5					Lamothé, Nunes [3-29]
101	73.4	21.1	7.92							Watson [3-30]
102	69.8	28.2	13.3							Watson [3-30]
103	10.4	40.0	13.0	0.65		0.40		4.14	19.08	Design Guide [3-31]
104	7.9	28.8	9.1	0.57		0.65		4.68	26.99	Design Guide [3-31]
105	6.0	11.0	7.0	0.54		0.76		5.39	35.28	Design Guide [3-31]